Power. and THE ENGINEER

EVERYTHING ABOUT THE GENERATION AND TRANSMISSION OF POWER

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IN the halcyon days when the steam-engineering trade was young, the best fireman was the lad who could heave the greatest quantity of coal onto the fire. But times have changed.

Engineers have always paid careful attention to the engine's performance. Indeed, builders would wage prodigious controversies over a matter of a fraction of one per cent. in the efficiencies of their engines.

During all this time everybody's back was turned against the possibilities of saving to be accomplished by a little attention to the source of the engine's energy.

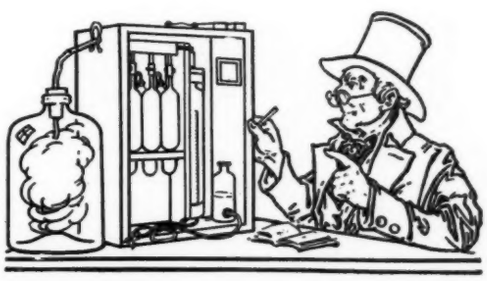
The boiler room was a dirty place at best, drafty and reeking with gas fumes. No wonder it was gracefully sidestepped for so long.

While the owners were "shopping" around trying to induce some engine builder to give them a guarantee of a small increase in efficiency, they were letting the firemen out there in the boiler room throw half the coal away.

But this state of affairs is rapidly passing.

The time is fast approaching when there will be a demand for as much brains and intelligence in the boiler room as there is in the engine room; in fact, we are not at all certain but that there may be a greater demand. Engines and turbines are so well equipped with automatic regulation of speed, steam and oil supply that after a unit is once started, it requires very little attention.

In the boiler room, things are different. Here conditions do not admit of very close automatic regulation. The quality of the coal varies, the intensity of the draft fluctuates, and the condition of the fire changes. Constant and skilful inspection and manipulation are required.



It is so easy to have poor combustion that in a great many plants the extent of the loss from this source is not even remotely suspected.

One of the best aids in studying the condition of the fire and estimating the completeness of combustion is flue-gas analysis.

Many people know this, others vaguely suspect it, but a big majority are blissfully ignorant. To the latter we commend these lines.

We think that the time is not far distant when in every large plant the performance of the boilers will be continually watched by an expert fireman. Temperatures will be observed, the gases will be analysed, every effort will be exerted, first, to induce the coal to "loosen up" every heat unit it is capable of giving off, and, second, to get just as many of those units into the steam as possible.

For the benefit of engineers who wish to know what flue-gas analysis means, what it shows and what the advantages to be gained from its practice are, we have published a number of articles. There was one in last week's issue. In this number there is another. There are others yet to come.

Boiler-room economy is coming rapidly to the fore. Flue-gas analysis is a means to that end. Why not collect a little information about it?

Heating a Shop through Its Floors

Novel and Successful System of Laying Iron Pipes for Steam or Ducts for Hot Air in Concrete Floor. No Radiators, Coils or Registers

No steam or hot-water radiators, no heating coils, no hot-air registers—the absence of these usual devices for heating a shop is the striking engineering feature of the buildings of the new plant of the Morse Chain Company, at Ithaca, N. Y. The foregoing sentence indicates an experiment in shop heating and a successful experiment it has been; yet the average heating and ventilating engineer would hesitate to try any kind of a heating experiment in a plant located and exposed as are the buildings shown in our halftone illustration, Fig. 1. The exterior walls of all these buildings are either of concrete blocks or monolithic concrete, in which the aggregate is crushed stone, a native slate quarried on the spot in preparing the foundations.

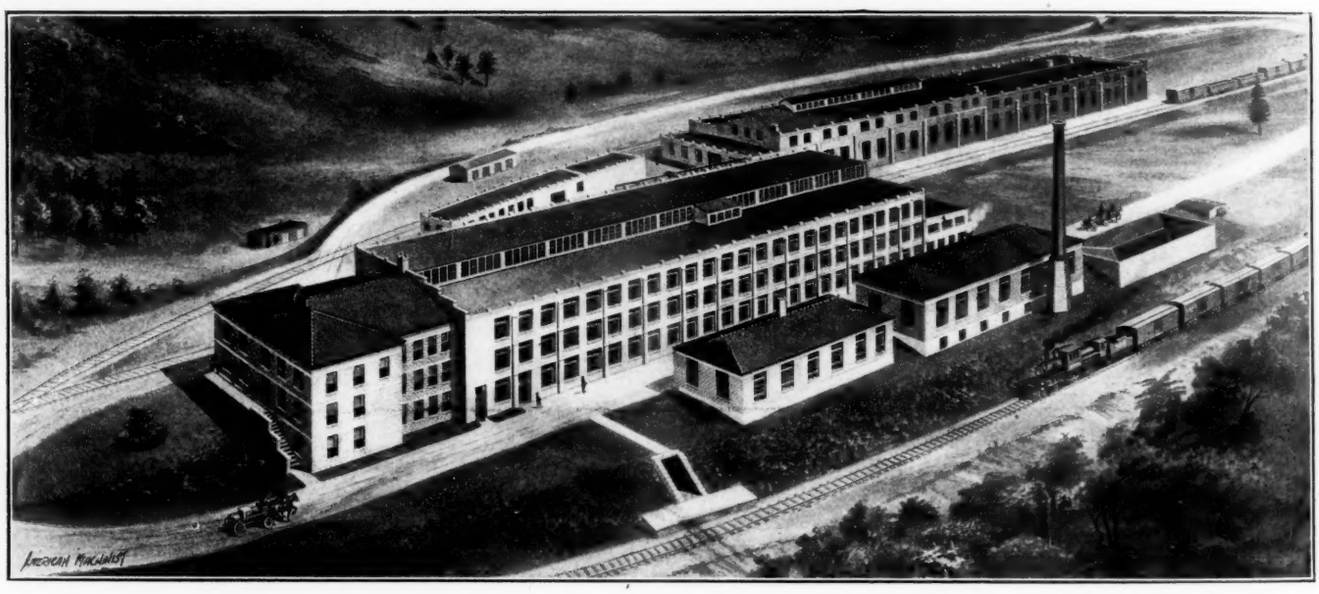


FIG. 1. PLANT OF MORSE CHAIN COMPANY, ITHACA, N. Y.

The city of Ithaca was located on the plain, at the southern end of Cayuga lake, and having outgrown this level site it has spread itself upon the surrounding hills; near the crest of a hill that swings around to the westward overlooking the plain below and the inlet of the lake is this new plant of the Morse Chain Company, finished and occupied early in the year 1906. As a beautiful site, with wonderful natural scenery, it surpasses any other site that we have ever seen used by a manufacturing plant. In fact, the natural development would seem to have been a country estate or sanitarium rather than a machine shop.

As regards the heating problem that we are to consider, from its location on the hill above the lake and from its exposure, which is toward the north and west, the buildings receive the full force of the winters' northwestern winds in a climate where the thermometer frequently registers 10 degrees Fahrenheit below zero, and where every winter brings a plentiful fall of snow.

STEPS IN DEVELOPING THE SYSTEM OF HEATING

It is interesting to follow the various steps in the development of this system of heating. The former plant of the Morse Chain Company was at Trumansburg, N. Y., and was heated in the usual manner, by an indirect system; that is, the blowing of hot air into the shops. The pattern shop was equipped with the customary glue pot heated by steam. The drip from this pot, as a mere matter of convenience, was carried through the floor and the condensed water was allowed to leach away into the gravelly soil. As a result of this arrangement, a small section of floor space around the glue pot was heated by the steam and hot water that escaped into the ground beneath. Mr. Morse noticed that this particular section of floor space was a favorite gathering place for the men; for those working in the pattern shop in working hours and others from the machine shops during the noon hour, when eating their lunches and having their after-dinner chat.

It became necessary to extend the pattern shop at Trumansburg and, following the observations made in connection with the glue pot and its waste steam and water, a system of 1-inch wrought-iron pipe was laid in the floor of the new pattern shop and connected back to the drip from the glue pot by a suitable system of valves. This system was put in with two ideas. A section of heated floor space would be of service in drying out the built-up wheel-pattern sections after they had been glued; at the same time, it was believed that the arrangement would serve as a satisfactory way to heat the shop. This shop was a roofed-over court between two main buildings. Aside from the heat which would be communicated to the floors from the system of pipes, no other provision was made for heating the room, except to make a few openings whereby air from the plenum of the main shop could enter.

This experiment was successful. Not only were the patternmakers satisfied with the method and degree of warming, but men from the machine shops would frequently come into the pattern shop to get warm, when the temperature of the air at about the level of a man's eye was 20 degrees less in the pattern shop than in the machine shop. There is an old adage in regard to health that runs something like this: "Keep your head cool and your feet warm." This system accomplished exactly that result; the men's feet were warmed from the warm floor, while the upper part of the room was

much cooler than if the system of heating had been by direct or indirect radiation. Their feet were kept warm and their heads were kept cool.

Heating of the Ithaca Plant

Three modifications of this system of heating through the floors are in use at the Ithaca plant. The pattern shop is heated by exhaust steam, traversing wrought-iron pipes laid in the concrete floor. The main machine shop is heated by hot air, forced through a system of supply and return ducts built in as part of the concrete floor structure, and the blacksmith shop is heated by a circulation of hot flue gases through a system of tile pipes buried some little distance below the floor of the shop. We will describe each of these systems in some detail, beginning with the pattern shop, as that is the simplest installation and more directly follows the successful experimental system at Trumansburg.

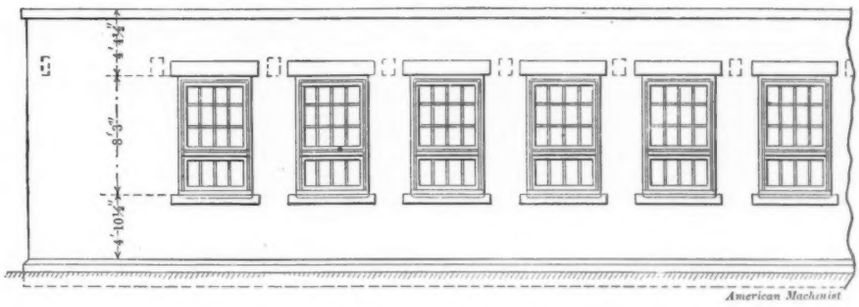


Fig. 3. Partial Elevation of Pattern Shop

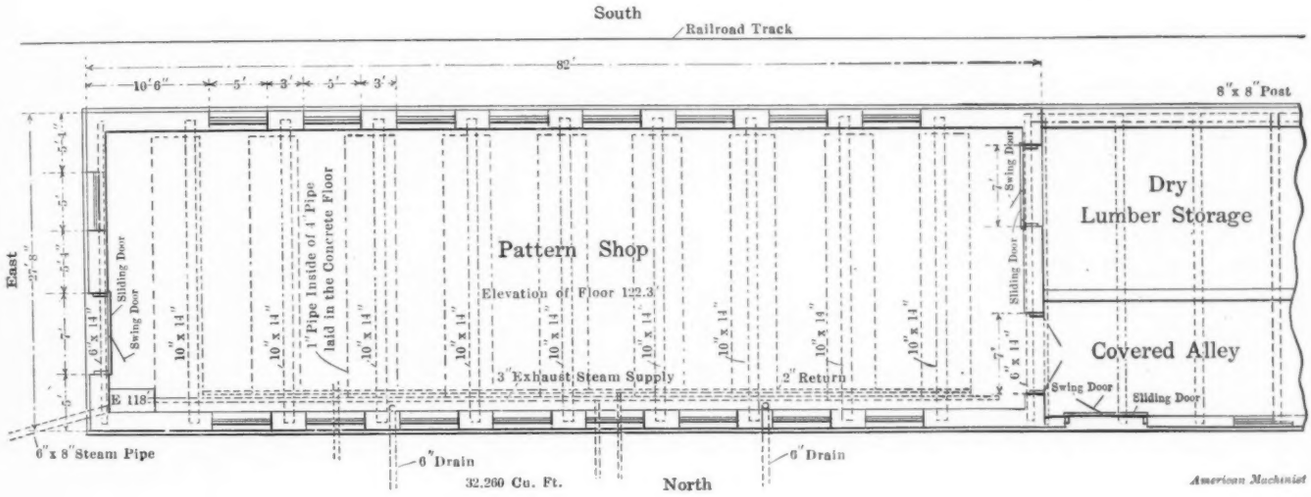


Fig. 2. Plan of Pattern Shop Showing System of Heating Pipes in the Floor

Heating the Pattern Shop Through the Floor

Fig. 2 shows the ground-floor plan of the pattern shop, with the piping system for heating, while Fig. 3 shows a partial elevation of the building, giving its hight, windows and general exterior details. This building is some 80 feet long, 22 feet 8 inches wide, and has a cubical content of 32,250 cubic feet. The walls are of monolithic concrete; the roof is of 3-inch plank, covered with composition roofing and the building is isolated, except for the southern end, where it joins a lumber-storage and a pattern-storage building. In fact, a portion of this end abuts on an open, though covered court. Along the western wall is a 3-inch exhaust-steam supply main; 1-inch pipes tap from this main run across the building, turn and run parallel with its length for a distance of about 5 feet, then turn again, cross the building again and enter a 2-inch return main that runs the length of the building on the same side as the supply main. The 3-inch supply main is at a level of about 1 foot above the floor. The crosswise runs pass through 4-inch wrought-iron pipe buried in the concrete floor, with a covering of about ½ inch of floor-wearing surface. The 5-foot runs lengthwise of the building are in an open gutter against the exterior wall; this gutter is covered with boards. Similarly the 2-inch return main is in a gutter along the opposite wall. The only exposed radiation in the room is the 3-inch supply main.

The total amount of radiating surface is 310 square feet, distributed as follows: Eighteen 1-inch pipes, 28 feet long, 161.4 square feet of surface; nine 1-inch pipes, 5 feet long, 15.5 square feet of surface; one 3-inch pipe, 84 feet long, 80 square feet of surface; one 2-inch pipe, 84 feet long, 52.5 square feet of surface, giving a total of 309.4, or, say, 310 square feet of radiating surface. Of this the 3-inch

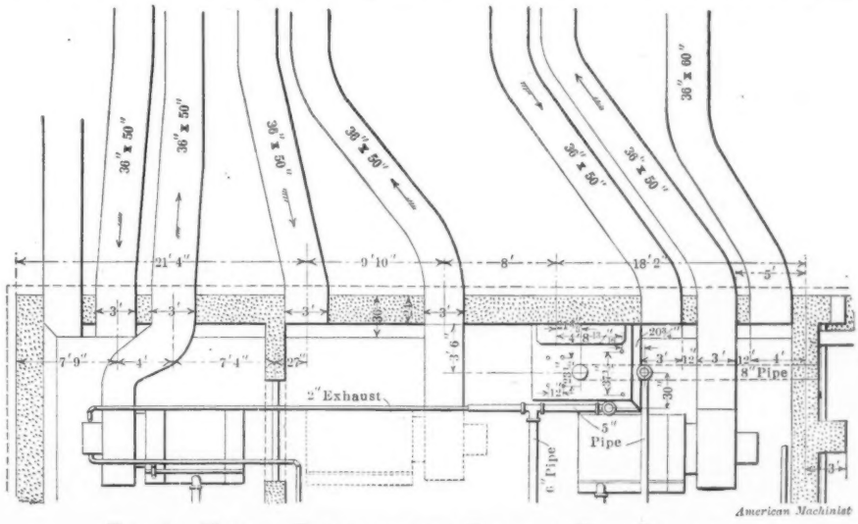


Fig. 4. Heated Chambers and Ducts to Main Building

main, or 80 square feet, is in the room itself, while the balance, 230 square feet, is in the floor.

The cubical contents of the shop are 32,250 square feet, giving approximately 104 cubic feet of volume per square foot of exterior pipe radiating surface.

A familiar heating factor frequently quoted in connection with factory buildings is that 1 square foot of direct radiation surface should be provided for 75 to 100 cubic feet of volume, with the accompanying note that isolated buildings exposed to prevailing northerly or westerly winds should have a generous addition made for their exposed sides. The factors are for latitudes where the minimum temperature range is minus 10 degrees Fahrenheit. Accepting these factors, we see that the amount of radiation provided to heat this pattern shop through the floor is slightly less than the minimum indicated for factory buildings that are not unusually exposed to severe winds or low ranges of temperature.

The steam pressure used is about two pounds back pressure. The following table shows the floor temperature, the temperature about the level of a man's eye and the temperature just under the roof, from observations made when the external temperature was zero and the prevailing wind was blowing from a northwest direction with a velocity of about 30 miles per hour. This shows what the system is capable of accomplishing. The lower part of the room as a whole is the warmest; that is, the part of the room where the men are at work. Again, behind these records stand three winters of successful use with the workmen perfectly satisfied with the temperature and conditions maintained.

January 4, 1910, minimum external temperature, 5 degrees below zero, maximum 11 above zero. Wind northwest 20 to 40 miles per hour.

PATTERN SHOP TEMPERATURES.
Temperature taken between heating pipes.

	7 a.m.	10 a.m.	1 p.m.	6 p.m.
1 inch above floor.	48°	52°	58°	59°
7 feet above floor.	48°	52°	58°	59°
Under roof.....	49°	53°	58°	60°

Temperature over pipes 1 inch above floor same day 7 a.m., 52° to 60°.

Heating the Main Shop Through Floors

The heating system of the main shop differs from the pattern shop in that it uses a circulation of hot air through ducts instead of a circulation of steam through pipes. Two heaters are installed, with space provided for a third (see Fig. 4), where the location for the third heater is indicated by dotted lines. The two that are installed are shown in full lines together with the system of supply and return ducts. The provision for a third heater is made to care for growth of the plant, as the two heaters now installed are more than ample for all the requirements of the main machine-shop building.

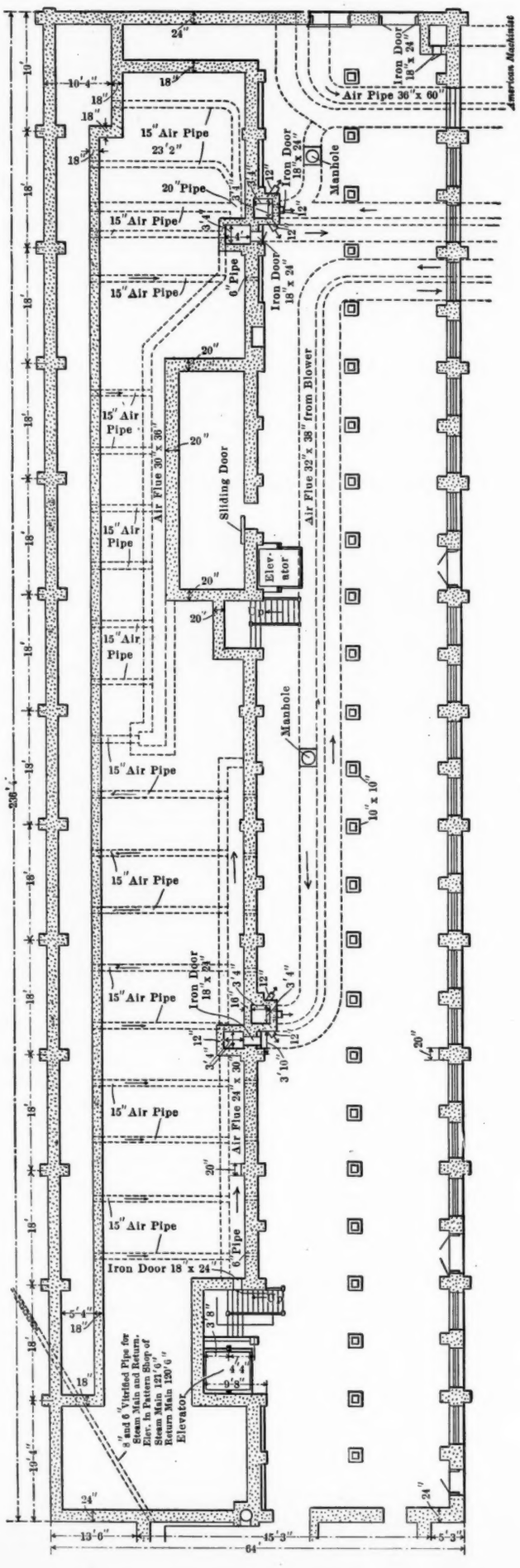

Air Pipe 36" x 60"
Iron Door 18" x 24"
Manhole
15" Air Pipe 23'2"
20" Pipe
6" Pipe
Sliding Door
Elevator
Air Flue 32" x 38" from Blower
Air Flue 30" x 36"
Air Flue 24" x 30"
10" x 10"
Iron Door 18" x 28"
Iron Door 18" x 24"
5" and 6" Vitrified Pipe for Steam Main and Return. Elev. in Pattern Shop of Steam Main 121'6" Return Main 120'6" Elevator
64'

FIG. 5. BASEMENT PLAN OF MAIN BUILDING SHOWING DUCTS AND PIPES BENEATH THE FLOOR

Fig. 5 shows the basement plan of the machine shop. The point of entrance of the ducts will be seen in the lower right-hand corner. The supply ducts connect with large chambers forming vertical flues at various points as seen on the drawing, and these in turn connect with a system of 15-inch tile bell-and-spigot pipe laid with portland-cement joints. These pipes are directly under the concrete floor and cross the building to a point some 5 feet from the eastern wall, where they enter a large concrete duct running the full length of the building.

Fig. 6 shows a cross-section of the machine shop, which will be observed to consist of a crane floor, shown at the right, a main floor at the left, a gallery floor above the main floor, and below a basement.

Fig. 8 shows a section through a concrete duct entering a vertical flue and this in turn connecting into the 15-inch pipes that have been mentioned. Fig. 7 shows a galvanized-iron pipe with openings, two of which are located at such a level as to discharge air into the basement, two onto the main floor and two

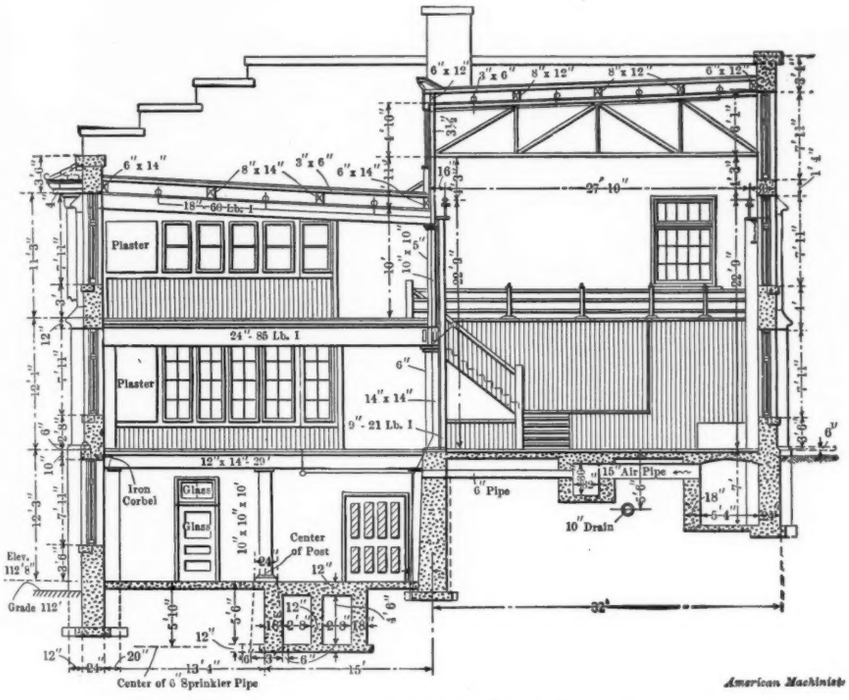


FIG. 6. SECTION THROUGH MAIN BUILDING

From this duct other 15-inch tile pipes run back to the return flues and thence to the large return duct that conveys the circulating air back to the fans. A study of the detail shown in Fig. 5 will make this system clear.

In passing it is worth while to note that the long duct near the eastern wall serves as a space for a long line of shafting from which the machine tools under the crane are driven through the floor by means of chains. A small amount of air finds its way through the belt or chain openings into the shop, but otherwise the circulating system is an inclosed system provided dampers in two vertical heating stacks, to be mentioned later, are closed. A system of butterfly dampers is installed in the large heating ducts, so that any duct can be changed from a supply duct to a return duct at will, as the needs of operating the system demand. Returning now to the right-hand end of Fig. 5, two of the ducts will be seen to end at the wall of the building. A continuation of these ducts will provide for the heating of an extension to the factory when such is built.

onto the gallery floor. These two stacks are the only provision made for distributing heated air directly through the room. When these two pipes are closed off, as is the case under ordinary shop conditions, even in the severest weather, no heated air comes directly into the machine shop, except such air as filters through the belt holes from the large duct along the eastern wall.

Turning now to the number of cubic feet of volume per square foot of indirect radiating surface; of the two heating plants one has coils with a combined heating surface of 2500 square feet; the other is larger, having a heating surface of 4840 square feet, giving a total of 7340 square feet for both.

The cubical contents of the main machine shop building, including the basement, is 514,500 cubic feet. This quantity divided by 7340 total area of radiating surface in both heater coils, gives a factor of 70 cubic feet of machine-shop volume per square foot of indirect radiating surface.

As a matter of fact, both fans are not used on heating this building except in severe weather and between the hours of 4 and 7 a.m. at which time the two vertical galvanized-iron pipes are employed and the air is recirculated before the workmen enter at 7 a.m. At that time the vertical stacks are cut off, the smaller heating plant is shut down and throughout the balance of the day the shop is warmed from the larger heating plant and entirely through the ducts and vitrified pipes beneath the floor. Dividing the cubical volume of the entire shop by the heating area of the larger plant, that is, 514,500 cubic feet by 4840 square feet, gives a factor of 106 cubic feet of volume per square foot of indirect heating surface. This is the factor that prevails under ordinary shop running conditions.

A frequently quoted factor for the amount of indirect radiation needed for factories in latitudes where a minimum temperature is 10 degrees Fahrenheit is from 50 to 70 cubic feet of volume per square foot of indirect radiation. The note quoted in connection with the pattern-shop factors applies here as well, and provides that isolated buildings, exposed to northerly or westerly winds should have a generous addition made to their heating provision for the exposed sides. The higher factor given is 70 cubic feet of volume per square foot of radiation. If this is compared with the factors worked out, namely 70 cubic feet of volume per square foot of indirect radiating surface when the plant is being warmed and 106 cubic feet during the day when the plant is in use, it will be seen that this floor system of heating requires no additional amount of heating

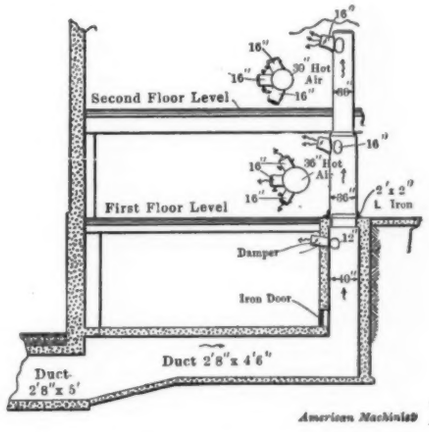


FIG. 7. SECTION THROUGH HOT-AIR STACKS

surface over accepted practice for other systems. In fact Mr. Morse states that the heating companies called for about double the radiating and fan capacity that he has installed. The success of the system is attested to by satisfactory use during the last three winters and the range of temperatures throughout the building compared with the outside temperature is shown by the following brief tabulation:

Temperatures were taken at a point 4 feet above each of the floors on Saturday January 8, 1910, the outside temperature at 7 a.m. being 4 degrees Fahrenheit; wind northwest, 6 miles per hour.

	7. A.M. Degrees.	12 M. Degrees.	6 P.M. Degrees.
First floor.....	62	59	64
Second floor.....	62	63	69
Third floor.....	64	67	73

The Blacksmith Shop

Fig. 9 shows a sectional plan of the blacksmith shop, which is heated by means of flue gases. Turning to this section, a No. 8 Sturtevant exhauster is indicated just below the level of the roof trusses. This exhauster sucks the flue gases from a large number of furnaces and forges and also draws a certain amount of air from the room itself through the space between the forge outlines and superimposed hoods. Under ordinary conditions this exhauster discharges directly through the roof by means of the short section of stack. In severe weather, however, a damper is closed, the heated flue gases are discharged through the pipe that follows the contour of the roof passing down to the ground. Turning to the plan it will be seen that the pipe running down to the ground is indicated as 18 inches in diameter. Flush with the level of the ground is the bell of a tee having one outlet on the run 18 inches in diameter and the other 15 inches in diameter This tee and the connecting pipes are vitrified tile sewer pipe. Starting at this tee the pipe runs in both directions around the shop near the exterior walls and discharges at one corner as shown. Through this piping the flue gases pass during cold weather and thus thoroughly heat the floor or ground in the blacksmith and forge shops. It is surely a simple, easy system to install and inexpensive to operate.

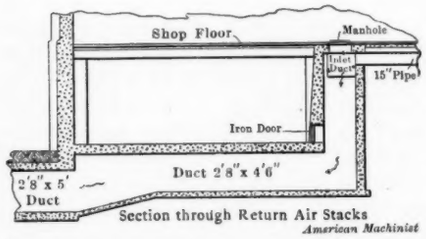


Fig. 8. Section Through Duct, Flue and Tile Pipe

Hard Floors or Cold Floors—Which?

Concrete floors, in their application to machine shops, have been investigated, approved and condemned, depending upon the attitude and inclination of the person having to do with the decision as to their use or non-use. The usual objection is that the floors are hard and that the feet and ankles of the workmen are quickly tired, and if they are asked to work on a concrete floor they will surreptitiously bring in boxes or boards or something else upon which to stand rather than stand upon the concrete floor itself. Again it is asserted that standing on concrete floors tends to bring on rheumatism.

The foregoing paragraphs, in regard to the heating system at once raise the question: Do workmen object to concrete floors because they are hard or because they are cold? In Mr. Morse's experience at the Trumansburg plant the men insisted on bringing in boards, boxes and the like to stand upon and even went so far as to wear heavy rubber overshoes during the working hours. That shop was heated by an indirect system. In the Ithaca plant, with the heating system beneath the floor it has been found that the men do not use boards or boxes to stand upon, neither to they try to make any special provision for keeping their feet warm by additional clothing. Their feet are at all times comfortably warm because of the heat in the floors, therefore, it is natural to conclude that the objections raised to concrete floors in the past on the score that they were hard were really raised because they were cold; the workmen did not distinguish between the uncomfortable feeling caused by the chilliness of the floor and a feeling of fatigue or tiredness which they supposed existed because the floor upon which they stood was hard. If this conclusion is true the only valid objection that has ever been urged against concrete floors for machine-shop purposes can be easily overcome.

Fig. 10. Suggested Form of Duct for Floor-Heating Pipe

Extensions of the System

It should be noticed that this heating system is applied to buildings one story in hight, as the pattern shop and blacksmith shop, or one story in hight with galleries, as in the main shop. Its application, therefore, to a multi-story building might need careful consideration and planning.

The simplest and cheapest installation of this kind that can be proposed is the forming of small ducts in the concrete floor by using a light sheet metal form as shown in Fig. 10 and then running through these ducts circulating pipes for an exhaust-steam direct-radiation system employing a vacuum pump to establish and maintain circulation.

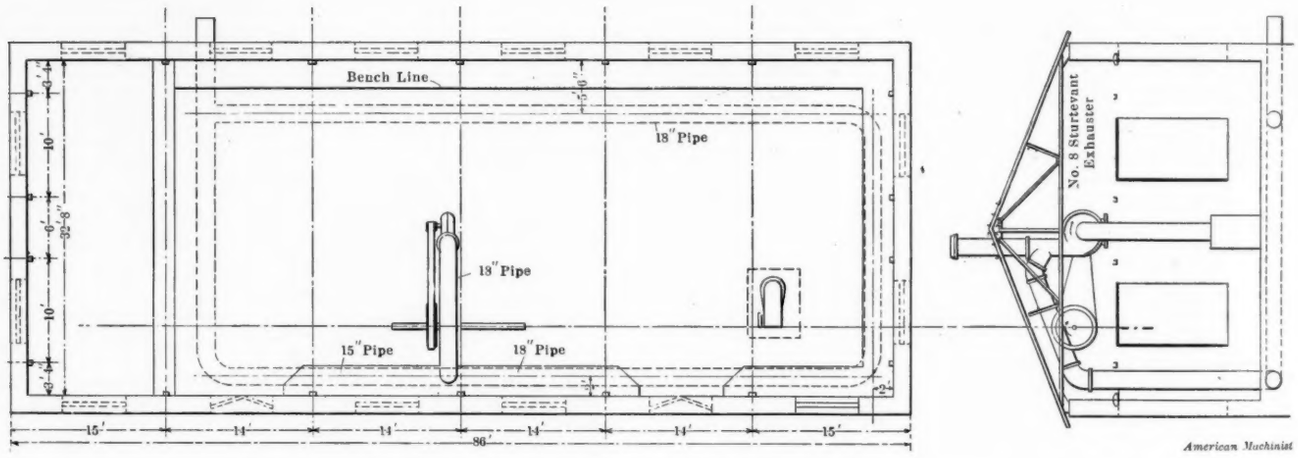


Fig. 9. Floor-Heating System of the Blacksmith Shop

"O'Brien," said Casey, "did ye hear that Hinnissey, down t' th' power house kim near t' gettin' foired?"

"No!" said O'Brien, "How did it happin?"

"Whin he stharted th' ingin last noight," said Casey, "it pounded, an' th' super' towld Hinnissey t' sthop it and kay up th' chrank. Hinnissey had bin takin' a few dhrinks, an' whin he wint around t' th' chrank he saw two av thim—an' he kayed up th' wrong wan."

An Old Boiler and Engine Plant

Charleston, S. C., is noted for its antique buildings, some a century old, but one would hardly expect to find boilers of the old shell type still in operation and apparently doing as good work as when installed, thirty-four years ago.

A view of the boiler fronts is shown in Fig. 1, which unfortunately shows that the fires have been drawn, although the writer saw the boilers under steam pressure the day before the photograph was taken. It will be seen that there is not

Operated in connection with these steam boilers is what is said to be an original Watt steam engine, brought over from England and set up in 1840. It was overhauled in 1854, when a larger cylinder was put on, and since that time it

FIG. 1. BOILER FRONTS

FIG. 2. VIEW OF ENGINE FROM SECOND FLOOR

Such, however, is the case. Located on the water front is an old-time rice mill which is still in operation and where are to be found four old-time shell boilers, each 36 inches in diameter and 38 feet long, carrying the enormous (?) steam pressure of 22 pounds.

even a single flue through the center of the boiler, and that there is no water glass upon any of them. The fireman determines the water level by means of gage cocks, of which the two end boilers have two each, while the two center boilers have but one apiece.

has been working with practically no repairs.

Fig. 2 shows what little can be seen of the engine from the second floor. The engine really is three stories high. The engine runs at 30 revolutions per minute and is rated at about 35 horsepower.

A New Condenser—Intake Tunnels

Steam Travels Only 3 Feet from the Exhaust Nozzle of the Turbine before Coming in Contact with the Water in the Condenser

BY R. D. TOMLINSON

Until very recently the extent of the floor space occupied by condensing apparatus used in connection with steam turbines has been a very serious handicap to the designer of the power plant. This is especially true of the surface type of condenser with its circulating hotwell and dry-air pumps. The distance between the centers of the turbine units in the power plant was fixed not by the requirements of the turbine, but by the amount and size of the condensing apparatus in the basement. In many cases there has not been room enough for all the machinery in the basement and it has been necessary to place part of it on the main floor of the engine room.

The condenser illustrated herewith is so designed that all the condensing apparatus, exclusive of piping, is placed entirely beneath the turbine and between the foundation columns. This makes it possible to set the turbines as closely together as may be desired.

The condenser head is cylindrical in shape. It is supported by columns or I-beams so that its axis is horizontal. The exhaust opening is at the top and at one end of the head and is connected directly to an expansion joint. This, in turn, is bolted to the exhaust opening of the turbine. With such arrangement all the exhaust piping is eliminated and limits the necessary joints to the two which are required for the expansion connection. This is a very important feature, for it meets the demand for the least possible number of joints between the exhaust nozzle of the turbine and the condenser, thereby reducing the opportunity for leakage of air and consequent impairment of vacuum.

Of much greater importance than the small number of joints is the short length of passage from the exhaust nozzle of the turbine to the condenser and the elimination of all elbows and piping. The steam travels only about 3 feet from the exhaust nozzle of the turbine before coming in contact with the water in the condenser. With this arrangement there can be no appreciable difference in pressure between the condenser and the exhaust end of the turbine. It is not, however, possible where elbows, tees and long lengths of exhaust piping are used, for it is obvious that steam cannot flow through a pipe without a difference of pressure.

There are many condensers connected to steam turbines in which the drop in vacuum between the condenser head and the exhaust end of the turbine causes serious loss of power. It is well understood that the highest possible

vacuum is necessary in order to obtain the maximum efficiency of the turbine. Therefore, it is bad engineering practice to purchase high-vacuum apparatus and lose part of the results aimed at by introducing a long and tortuous passage through which the steam must pass from the exhaust end of the turbine to the condenser. There are some locations, in existing plants, where the depth of the basement will not accommodate the usual setting of the turbine and condenser without modifications. Sometimes it is necessary to raise the turbine above the floor level or else place the pumps in a water-tight pit in the basement. Either of these plans accomplishes the desired results and is a better arrangement than placing the condenser at the side of the turbine or at distant points which necessitate crooked or long exhaust piping.

The condenser shown is supplied with two centrifugal pumps mounted on the same shaft. These are driven by a motor or small steam turbine direct-connected to the pump shaft. The shaft runs in ring-oiled bearings which insures long continuous service with a minimum amount of trouble and attention. The pumps are of different capacities. The larger removes the water from the condenser and discharges it into the hotwell. The smaller pump takes water from the cold-water supply and discharges it through a specially designed air-ejector nozzle to the hotwell. In this way the air is removed from the air and water separating chamber of the condenser and discharged with the water. In other words the ejector nozzle serves the purpose of a dry-air pump. In cases in which the supply of water is limited, the water from the ejector may be returned to the cold well. A special arrangement which removes the air from the water makes this possible, and permits the complete utilization of all the water available. It is recommended, however, that, wherever possible, the water used in the ejector nozzle be discharged into the hotwell.

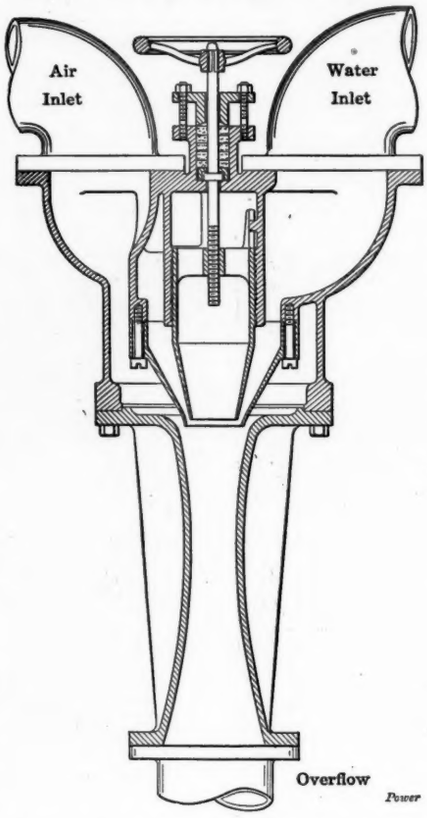


FIG. 2. AIR INJECTOR OF TOMLINSON TYPE C CONDENSER

The accompanying sketches show one of these condensers attached to a standard turbine, also the general arrangement of the condenser head and air ejector.

The condensing water enters the water box at the left of the condenser head, through the injection inlet. From here the water flows through several troughs which run lengthwise of the head and which are a little above the center line. These troughs have serrated or notched sides which permit the water to overflow in a series of thin streams. As the water falls from the troughs it meets the entering steam, which has high velocity, and strikes the splash plates with great force. This breaks it up into a fine spray. The air contained in the water is freed as soon as the latter enters the water box, and passes directly to an air chamber from which it

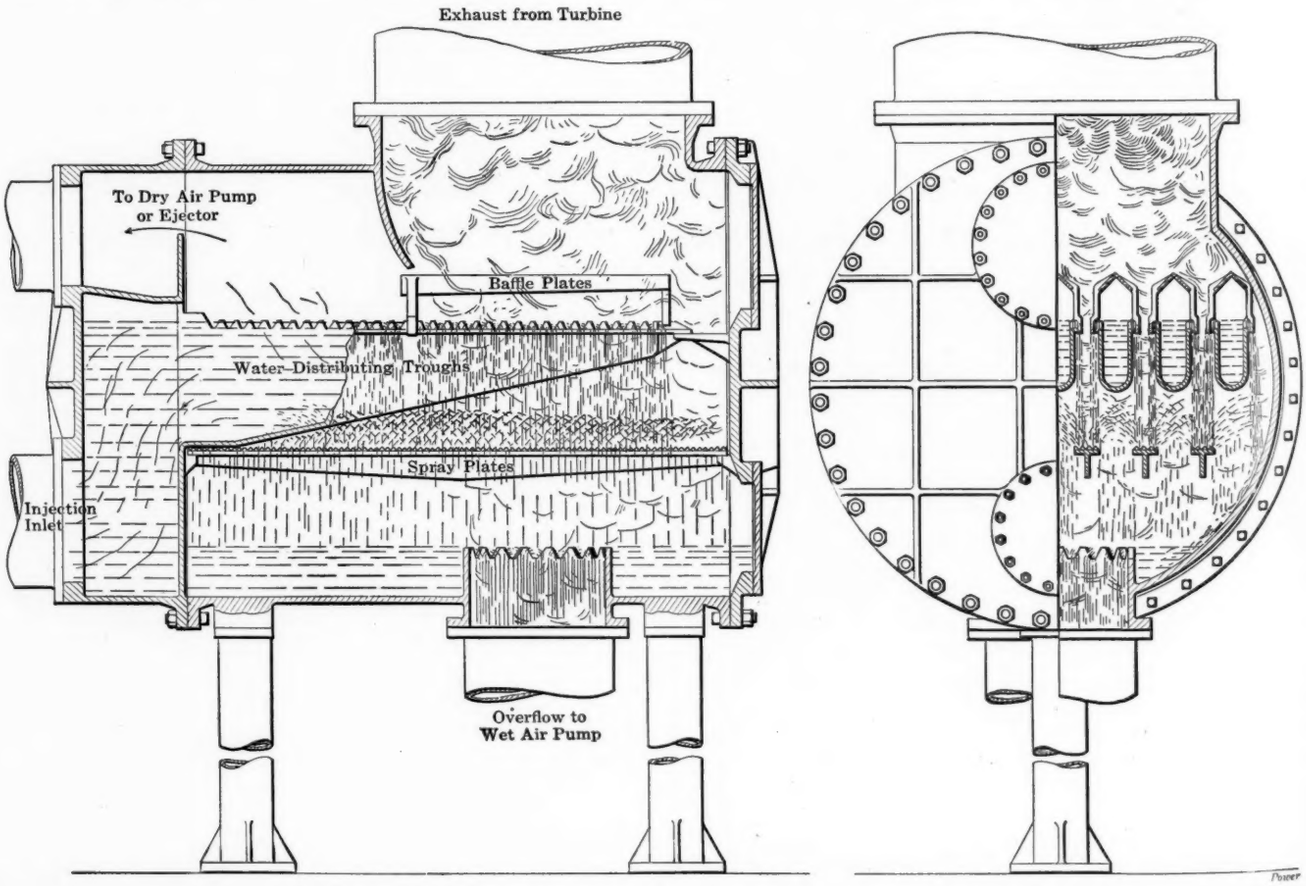


FIG. 1. A NEW TOMLINSON CONDENSER ESPECIALLY DESIGNED FOR USE WITH TURBINES

is removed through the suction line and air ejector previously mentioned.

The steam enters at the top of the condenser and passes down between baffle plates placed over the water troughs. These baffles prevent the water in the troughs from being displaced due to the velocity of the entering steam. As the steam passes downward between the troughs it mixes to some extent with the descending streams of water, and when the splash-plate is encountered there is a thorough and intimate mixing of the steam and water. The water and condensed steam fall to a collection chamber at the bottom of the condenser where the water is maintained to a depth of a few inches. This prevents any erosive action on the condenser shell if grit should be present in the water. The hight of the water is determined by the arrangement of the discharge pipe which is carried up into the condenser several inches. The top of the discharge pipe is notched so that the water flows over it in a ragged stream. Any steam left in this portion of the condenser will thus have a better chance to mix with the water and will tend to produce a better vacuum. The air, which enters the condenser with the exhaust steam, passes to the left and up between the troughs to the air-collection chamber and is removed with the air coming from the water.

The general design of the air-ejector nozzle used with the condenser is shown at the left in the sectional view. It is so arranged that the air comes in contact with both sides of the projected hollow stream of water, thereby nearly doubling its power to remove air. The narrow water openings are the only portion of this nozzle which might ordinarily cause trouble if they should become clogged with dirt or foreign material. With this design the inner nozzle can be drawn back by turning the handwheel. The size of the opening is then increased sufficiently for the water to wash out the foreign material, after which the nozzle can be turned back to its original setting. All of this can be done without interfering with the operation of the condenser in any respect.

The air-ejector nozzle and its pipe connections perform a very useful service other than assisting in creating high vacuum. They also serve as a vacuum-breaking device in which no moving parts are required. If the water pumps should stop from any cause, the check valve in the discharge of the main pump would immediately close; the water flowing through the second pump to the air-ejector nozzle would cease flowing and the air would rush back through the suction line to the condenser. This would break the vacuum before it would be possible for the condenser to flood, and prevent water getting up into the exhaust end of the turbine. This has been the cause of a number of steam-turbine wrecks. Nearly all so-called automatic vacuum-breaking devices depend upon a float which opens a valve admitting air. Before this action takes place, the condenser must be flooded sufficiently to raise the float. It frequently occurs that the float or valve sticks and flooding occurs. In the design shown the air rushes back and breaks the vacuum the instant the pumps stop.

The value of a condenser depends upon its reliability and its efficiency. The first is of especial importance when used in connection with a steam turbine; for, if the condensing apparatus is not designed in a manner to permit of continuous service, the turbine unit falls short of operating requirements. When such apparatus requires an undue amount of attention, frequent inspection and overhauling, cleaning out of contracted water passages or the renewing of pump valves, its continuous operation is an impossibility and its reliability is uncertain. Such troubles necessarily involve a decrease in the vacuum it is possible to maintain, with a consequent reduction in the efficiency of the turbine; for a turbine operates most economically with the highest vacuum.

This type of condenser, due to its small number of parts, the absence of pump valves and reciprocating parts, and the use of large passages, enables it to fulfil the most exacting requirements.

Another important factor in the efficiency of condensing apparatus is the quantity of injection water used to condense the steam. There are many places in which water for condensing purposes is limited, and in nearly all cases it has to be pumped. If more water is used than is actually required in accomplishing the condensation of the steam, the pipe lines and all parts of the apparatus have to be larger than would be the case if the water consumption more nearly approached the theoretical amount. The quantity of water required to absorb the heat in the steam and condense it is controlled by the ability of the conden-

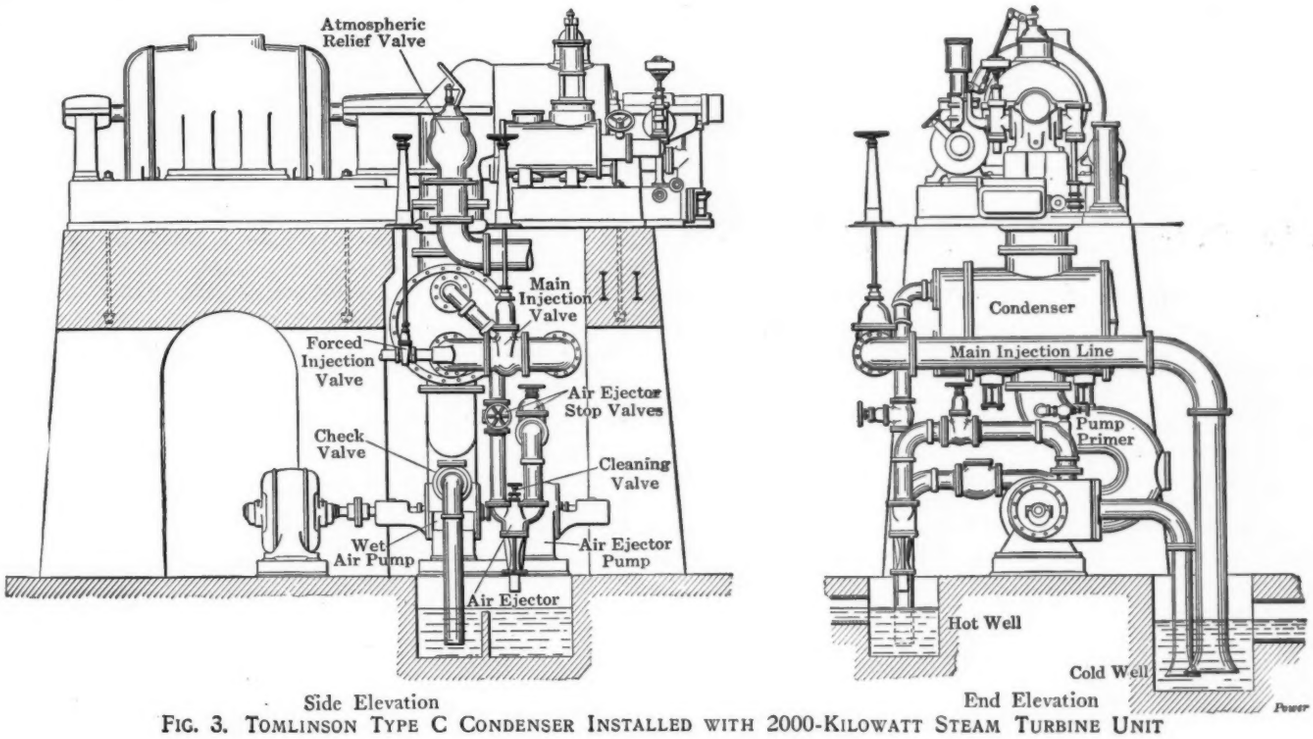


FIG. 3. TOMLINSON TYPE C CONDENSER INSTALLED WITH 2000-KILOWATT STEAM TURBINE UNIT

ser head to intimately mix the water and steam. The condenser shown accomplishes this, mixing in an ideal way, as provision is made for the steam to enter the water both before and after it strikes the spray plate. The theoretically perfect condenser would permit the condensing water to absorb heat until the discharge water was at the same temperature as the exhaust steam. This condition is hardly attainable; but the water leaves the condenser above described at but slightly lower temperature than that of the exhaust steam entering it.

The failure to produce satisfactory vacua is in many cases due entirely to faulty arrangment of the injection water system and the piping connecting it to the condenser. In all cases the water supply should be brought by gravity to a point as near the condenser as conditions will allow. There are many different methods of accomplishing this result. The best plan is to build a tunnel beneath the basement floor and provide openings opposite each of the condenser units. With this arrangement the injection pipe becomes very short and direct and this will reduce troubles from leaky joints to a minimum. Also if changes should require the removal of the pipe, its short length reduces the labor required. In some installations the tunnel is made comparatively small but is increased in size to form a well wherever injection piping enters it. This arrangement does not obstruct the flow of water to units farther along the line of the tunnel. A very good arrangement is to build the wells at one side of the main conduit or tunnel, as this allows a smaller diameter of conduit than would otherwise be the case. The wells mentioned should be considerably deeper than the conduit so that the mouth of the injection pipe will be sufficiently submerged to prevent the admission of air. It should be at least 6 feet from the surface of the water to the entrance of the pipe and a greater distance is preferable. The velocity of the water entering the mouth of the pipe should also be reduced as much as possible. This is best accomplished by making the mouth of the pipe twice its diameter and thus making the entering velocity one-fourth that in the pipe.

Where conditions will not permit of the construction of a supply conduit beneath the basement of the building, cold-water basins fed by gravity should be placed as close to the station as possible. The wells and supply piping should be made of sufficient size so that under no circumstances will the level of the water be reduced low enough to permit air being drawn into the pipe.

In all cases long suction lines to either pumps or condensers should be avoided as they are sure to produce air leaks through the many joints. The expansion and contraction of the suction line will cause undue strains to be thrown on the joints. In many cases these are severe enough to crack the flanges and in nearly all cases will open up the joints. Long suction lines, especially if the lift is high, result in more or less trouble and are a serious handicap to good operation of condenser outfits. It is wise management to invest any reasonable amount of money to eliminate such undesirable and troublesome conditions.

Future Development of the Steam Turbine

Best Designs of Impulse and Reaction Turbines Equally Reliable. Relative Importance in Future Will Be Settled Mainly on Considerations of Price

In steam turbines constructed for driving electric generators in central stations, there has been great improvement during the past year, not only in constructive features but also in the economy of operation. As these data indicate the lines along which future developments will be made, the following, reproduced from *Engineering*, of London, may perhaps be of interest.

When the trials of the famous Elberfeld turbines were made in 1900, the steam consumption, which in the best test amounted to 19.42 pounds of steam per kilowatt-hour, constituted a record, and was, indeed, a very remarkable result in view of what would now be considered the moderate dimensions of the unit and the fact that it was the first of the size to be constructed by its builders. Station engineers nowadays have, however, less generous views as to where the dividing line should be drawn between a merely healthy and an abnormal appetite for steam. Improvements in condensers have largely helped the turbine builder to meet the increasing demands of his customers in the matter of steam economy. In the early days the importance of a good vacuum to turbine efficiency was little realized by station engineers, and builders used to pray for a low barometer during the period of the reception tests, as few ever bothered to reduce to absolute pressure the readings of the vacuum gage, so that the turbine obtained its rated consumption with a vacuum which, to all appearance, was nothing out of the common. The growing use of superheat has also contributed not a little to the success with which higher steam economies have been obtained, but probably more important than either has been the increase in the size of the units.

As a result of these different factors, for instance, Messrs. Howden & Co., with the 6000-kilowatt Zoelly turbine, at Manchester, have been able to generate one kilowatt-hour with the equivalent of 13.8 pounds of steam, supplied at 186 pounds pressure, 140 degrees superheat, and exhausted at a 28-inch vacuum. Even better results in actual steam consumption have been recorded with the 9000-kilowatt Curtis set at Chicago, where the actual steam consumption was under 13 pounds per kilowatt-hour. Figures of this kind require, however, adjustment for the various factors involved, and the actual efficiency ratio (governor valve to switchboard) at Chicago was about 62 per cent., the remarkably low consumption of steam being due to an equally remarkable vacuum of 29½ inches, corresponding to a condenser temperature of only 60 degrees Fahrenheit. The efficiency ratio of the Zoelly turbine at Manchester is stated to be 69.2 per cent., reckoned from governor valve to switchboard; and in a paper read before the Association of Engineers-in-Charge on December 1, G. B. Williamson has claimed this figure as a record. It would, however, appear to be surpassed by the figures obtained with the new 6000-kilowatt units installed at Lot's-road by C. A. Parsons & Co., where, with very similar conditions at the stop valve and a vacuum of 27.7 inches, the consumption was 13.7 pounds per kilowatt-hour.

Theory indicates that, leakage losses apart, the reaction turbine should have a sensible superiority, and the close results of the rival systems seem to indicate that the greater efficiency of the reaction turbine at the low-pressure end is discounted by the losses by leakage in the high-pressure section, where the steam is dense and the blades are short. A combination of an impulse high-pressure end with a Parsons low-pressure section may, therefore, ultimately prove to be superior to either type pure and simple.

The Melms-Pfenninger turbine is, of course, constructed on these lines, and has given very good results. There are, however, some practical advantages in the adoption of a velocity-compounded wheel for the impulse section, which may, in certain cases, lead to this construction having the preference in spite of its lower efficiency. Where very high

pressures and great superheats are to be used, the use of a velocity-compounded impulse wheel makes it possible to confine the extremes of pressure and temperature to a mere nozzle box, in place of admitting them to the shell of the turbine proper. Large turbines, very much on the lines suggested, are now being constructed by the Allgemeine Electricitats-Gesellschaft, in which a single velocity-compound wheel constitutes the first stage of the turbine, while the low-pressure end is a drum fitted, however, with impulse blades, though there is much reason to believe that the Parsons system would here have considerable advantages, its leakage losses being no greater, while its blade efficiency is higher. The advantages of the particular combination suggested belong rather to the facility it gives for the use of extra high-pressure steam than to the attainment of exceptional efficiency ratios. If, however, a turbine is constructed so that it can utilize a heat drop of 450 B.t.u. with an efficiency ratio of 64 per cent., it will exceed in steam economy another turbine having an efficiency ratio of, say, 70 per cent., but capable of utilizing down to the same condenser pressure but 380 units of available heat.

This distinction between steam economy and efficiency ratio is well illustrated by recent marine practice. The steam consumption of the most recent Curtis marine turbine as fitted to a battleship is very little more at full power than that recorded with the "Dreadnought." The latter, however, ran with its steam wire-drawn in the steam chest down to 150 pounds, though the boilers were supplying the steam at 240 pounds; while in Curtis sets, at full load, practically the full boiler pressure is generally admitted to the turbine. With not much difference in actual fuel consumption, therefore, the efficiency ratio of the reaction turbines must have been considerably the greater. This drawback, which is inevitably associated with the principle of velocity compounding, is largely discounted by the facility with which large quantities of "available heat" can be dealt with. By the adoption of blade speeds exceeding 600 feet per second the Allgemeine Electricitats-Gesellschaft have thus secured excellent steam economy with a turbine having two pressure stages only. Blade speeds have also been raised in impulse turbines having no velocity stages, and in units of large size are now often about 400 feet per second. High blade speeds involve, of course, shorter and cheaper turbines. With the reaction type, the advance in this regard has been less marked , but the question as to whether it will be prudent to reduce the factors of safety against centrifugal forces seems worthy of consideration. So far as the blades themselves are concerned, the safety, even at greatly increased speeds, seems absolute if they are calked in the usual way; though some of the systems which involve the use of a foundation ring are perhaps less satisfactory in this regard. With these, the drum is cut away more, and the "dead" weight to be carried by it is increased. A properly calked blade will break in two before it will pull out. As to the drum stresses, again, these could probably be raised without danger of a burst. The load on the drum is perfectly steady; and if the emergency governor fails to act in a runaway, a complete smash-up is inevitable, whatever the normal working stress may be. The real difficulty of using higher surface speeds would seem to be due rather to questions of distortion than of strength, and such increase might necessitate larger clearances in the dummies and over the blade tips.

The small clearances often raised as an objection to the Parsons turbine appear to have lost their terrors with the introduction of the blades having thinned tips, and the system of assembling the blades in sections, which are then transferred bodily to the turbine body, has made it possible to silver-solder a lacing wire to even the shortest blades. This was previously impossible, since, in the case of short blades, the heat was conducted away too rapidly into the heavy mass of metal constituting the drum or the casing.

Had these or equivalent improvements not been effected, there would have been little occasion for surprise if the reaction type had had to give way to the impulse pattern. Some of the latter have, no doubt, had their troubles, but these were relatively less serious than with some of the earlier patterns of the Parsons machine built before designers had realized the difficulties which supervened on the general introduction of superheated steam. Had these not been surmounted, the lower cost of construction and the higher efficiency ratio possible with the reaction type would hardly have saved it from supersession. It has undoubtedly been more difficult to construct free from risks of injury than was the impulse type, and variations made from the original designs by licensees and others have often been injudicious. As matters stand, however, the best designs of both types are now probably equally reliable—certainly the reaction type stands at no disadvantage—and their relative importance in the future will be settled mainly on considerations of price. Cases, no doubt, are still recorded of reaction turbines giving trouble, but these are invariably old patterns, in which sufficient provision was not made for the distortions caused by superheat. Bronze foundation rings, for instance, if used at the high-pressure end of a turbine, are liable to work out if the superheat is considerable, owing to differential expansion. By substituting steel rings here the difficulty disappears.

In marine work it is necessary to distinguish between the case of the mercantile marine, where boats are driven at constant speed, and the navy, where most of the steaming is done at a speed very much below the maximum. So far as data are at present available, it would appear that for the former condition of affairs the reaction type weighs less for a given steam economy at full load than its rival, though the matter is complicated by the fact that the comparison has to be made between two-shaft and three-shaft or four-shaft systems. In naval work the impulse type seems to provide for cruising speeds more simply than has yet been done with the reaction type. This may be altered by the introduction for this service of Mr. Parsons' partial-admission reaction turbine; but, failing that, we should not be surprised to see the adoption of a combination system consisting of a number of high-pressure velocity stages followed by a low-pressure reaction turbine.

At the recent annual meeting in Boston of the division of Industrial Chemists and Chemical Engineers of the American Chemical Society, a committee was appointed by the chairman, under authority of the bylaws of the section, "On the Definition of Industrial Terms." In constituting this committee, it is the desire of the division that it coöperate as far as possible with trade organizations in the several lines of industry in formulating definitions of their products which shall be as accurate and as fair as possible to the interests involved. The organization of such a committee has been suggested by various interests who desire a more authoritative definition of some industrial terms such as "petroleum ether," "gasoline," "gasolene," "benzol," "bronze," "benzine," "steel," "portland cement," etc. It is proposed, when an interest is expressed for the definition of terms in any special field of industry to organize a subcommittee to consider this field and define the principal terms in use in it. The general committee is desirous of receiving suggestions from all who are interested in the subject as to terms which are considered the most important to be defined at the present time, owing to ambiguities which may now exist, and as to the best methods of accomplishing the work. The value of authoritative definitions as approved by the industrial division of the American society will, of course, be recognized. Communications should be addressed to Clifford Richardson, 30 Church street, New York City.

Jacketing a Cracked Concrete Chimney

From the point of view of the power plant there are some valuable practical lessons in the experience which the Winchester Repeating Arms Company, of New Haven, has lately had with a defective concrete chimney, and with the problem of repairing this chimney. The original concrete chimney rested on a brick foundation which was part of the power-house building. Above this brick foundation the chimney rose about 80 feet. It had an inside diameter of 4 feet and was unlined. At the base it was spread to an outside diameter of 8 feet and at the top to 6 feet. The greater part of the intermediate length was cylindrical, with walls about 4 inches thick. The old structure was reinforced according to the method common in the practice of five years ago, but its defects were due to the character of the concrete mixture employed. This was a stiff, dry mortar, without stone, and it soon developed longitudinal cracks so roomy that smoke escaped at times through them, and at other time enough air was drawn in to affect seriously the efficiency of the draft.

FIG. 1. PUTTING ON THE JACKET

The mortar itself deteriorated rapidly, becoming so soft and "punky" that it crumbled readily under a smart blow from a hammer.

The Aberthaw Construction Company, of Boston, undertook last fall to put a reinforced-concrete jacket about the old chimney, and the details of their method constitute a valuable guide for similar construction. The jacket was 5 inches thick over the whole of the old chimney above the brick foundation. The vertical reinforcement consisted of 32 steel rods, equally spaced, and inclosed by horizontal hoops 6 inches apart.

Before the first section of the concrete jacket was applied the old chimney was carefully wrapped with asbestos felt. This served a double purpose, acting first as an expansion joint between the old and new structures, and serving also to protect the green jacket against too rapid drying by the heat of the inner shell, and against the drawing of moisture from the green concrete into the old chimney.

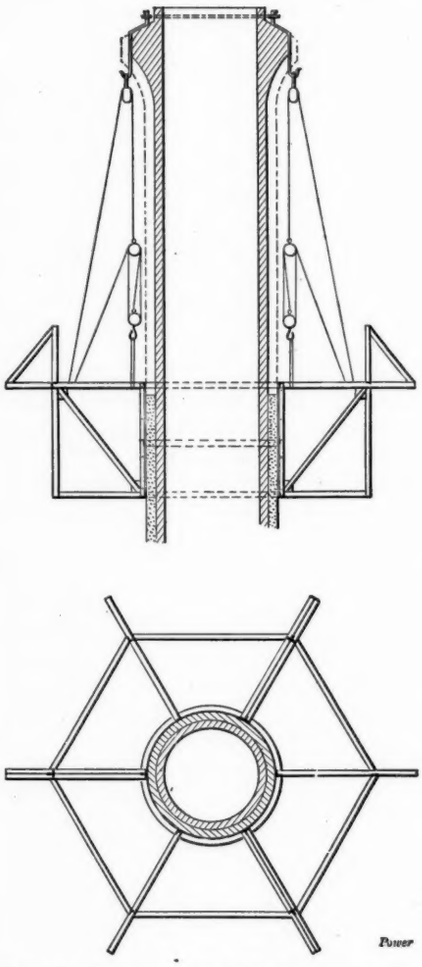


FIG. 2. SECTION OF CHIMNEY, JACKET AND IRON FORM, WITH STAGING

The other aspect of the work, which is of especial practical value, was the ingenious construction and operation of the form used on the cylindrical portion of the chimney. The form proper consisted of a cylinder of 16-gage iron, 5 feet high, with an inside diameter of 5 feet 8 inches. This was made in three equal sections divided vertically. The horizontal framing consisted of three 2x2x¼-inch angles rolled to a true circular arc. Each section of the form proper therefore constituted a cylindrical surface of 120 degrees braced horizontally by the curved angle bars, one at the top, one at the bottom, and one midway between. Extending horizontally from the top of each of these sections was built a platform braced diagonally to the bottom of the form section with 2x2x¼-inch angles, and resting on horizontal angle bars running to the upper corners of each section of the form. These three sections of form and staging combined were fastened together by bolts running through angle bars on the vertical edges of each section of the form and through the pairs of adjacent angle-iron supports under the platform. The form and the working platform were suspended by heavy ropes from three 12-inch single blocks, which were themselves hung from a heavy ring set on top of the overhang of the chimney. The cylindrical portion of the jacket, in which the form was involved, was made in the following manner. The asbestos having been applied over a hight of about 5 feet from the top of the cylindrical form, the form was then raised, and concrete was filled into the space between the form and the chimney and closely tamped about the reinforcing steel. The next forenoon the asbestos and steel were extended farther up the chimney, and the form was hoisted a distance of 4 feet 10 inches, leaving a lap of 2 inches on the concrete placed the day before. The concrete of the second day's work was placed in the afternoon, and was allowed to set until the next morning, when the form was again raised 4 feet 10 inches, and a new ring of concrete was placed that afternoon. The form and platform were prepared for hoisting by loosening the bolts in the facing angle bars which formed the three joints.

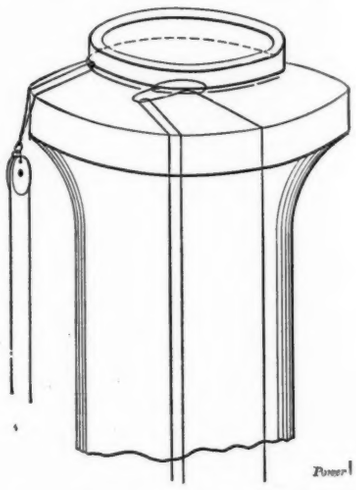


FIG. 3. ROPE SUPPORT FOR TACKLE

CO_2 Percentages and Economical Firing

Carbon Dioxide in Flue Gases Increased by Careful Firing and Variation of Draft with Load. Method of Obtaining Continuous Samples and a Bonus System

BY J. V. HUNTER

Within the past six months a number of articles have appeared in the columns of POWER, in which the writers have advocated the production of high CO_2 percentages in boiler flue gases, and as practically all the information which they have vouchsafed consists mostly of diagrams, showing the savings produced by high CO_2, it follows that most of the readers must, by this time, be familiar with the fact that they can save considerable money provided they can get similar results from their furnace fires.

It was a considerable time ago that we first took up this matter, at the Fort Wayne Electric Works' plant, and knowing that savings would result, we began work upon this subject about the same time that we were conducting boiler tests to determine the most economical coal for our furnaces. The tests were conducted simultaneously as we at that time had trained technical men in the power plant who could devote some attention to the work.

I do not think that 95 per cent. of the boiler plants about the country could show any better results at the present time than were obtained from our boiler fires, which showed that we were obtaining CO_2 percentages averaging from 3½ to 8 per cent., the high percentage being obtained only when the fires were in the very best condition. This high percentage was the maximum, the average being about 5 per cent., as we found by drawing a sample over a continuous period.

DRAFT

These boilers are now operated with induced draft, which affords many advantages over the ordinary stack draft, although we have boilers working under natural stack draft and on taking up the work later we found that it was possible to obtain equally as good results as with induced draft The great advantage to which the induced-draft system lends itself is that the amount of air passing through the fires can be regulated to take care of the load, and depth of fire, as well as by means of a damper control which is situated in the breeching. Practically all boilers which are of any size, are equipped with a damper in the breeching or in the uptake to the stack and it would be very hard to control the supply of air if it were regulated entirely by the ashpit or furnace doors.

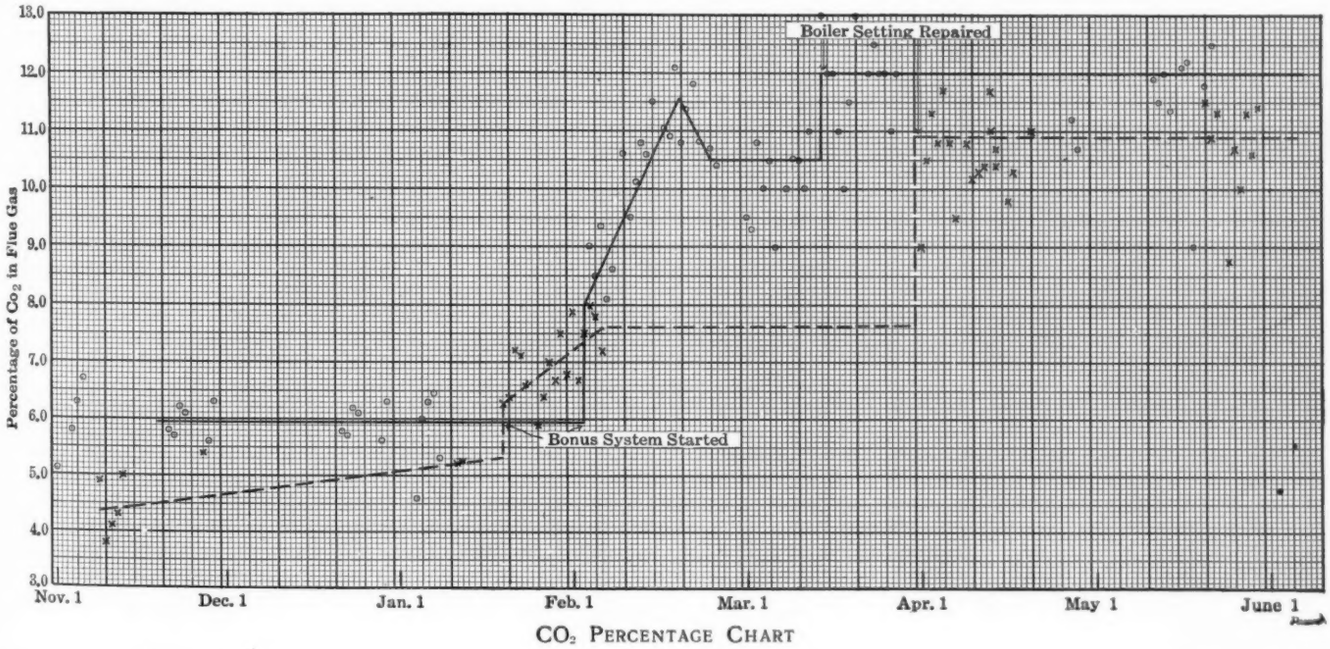
An induced-draft system, as installed by a fan company, is apt to have insufficient motor control, if the fan is electrically driven, so that additional resistance may have to be inserted in the armature circuit in order to slow down the motor sufficiently, and it will probably be found in taking up the work that better results can be obtained when the fan is slowed down below the speed which may at that time be normal running.

High percentages of CO_2 depend entirely upon the quantity of air passing through the furnaces, and that is why I have mentioned this subject of the control of the draft so particularly, as, in taking up this work, it will be necessary to exercise constant supervision over the draft, and vary it with the different loads, if high percentages of CO_2 are to be obtained.

FIRING

The second underlying principle of successful operation is that of careful firing with coal suited to the purpose. In hand firing a large furnace, it is probably impossible to find a fireman, who has not been trained to this particular work, who will fire the coal evenly over the whole furnace, taking care to cover up all the burned-out spots which may show. These burned-out spots are the entrances for the excess of cold air which passes through the grate and furnace without taking any part in the combustion except to cool the products thereof. Without careful instruction and an interest in his work, the fireman is very apt to neglect keeping these spots covered, as it means a more careful study of the blinding glare which shows in the furnace and often the use of smaller shovelfuls, so as to distribute the coal over the furnace more evenly.

Locomotive firemen often claim that they fire in such a manner as to keep the grate completely covered, due to the fact that when burned-out spots occur in a locomotive fire they have even more marked effect upon the steam-producing qualities of the boiler than with the stationary type. We have, however, had many locomotive firemen, who in dull seasons have worked with stationary boil-



CO_2 PERCENTAGE CHART

ers, and I have not noticed that they exercise any more care in keeping all the burned-out spots covered than does the ordinary stationary fireman.

The presence of clinkers on the grate, besides taking up valuable space which should be occupied by heat-producing fuel, also tends to prevent the air from coming in contact with the fuel. Ash and clinkers permitted to remain on the grate will necessitate a higher draft in order to force a requisite volume of air through the grate. The result of this will also appear in the fact that all leaks in the boiler setting, etc., will rapidly increase the volume of air which they pass, although no more air may be going through the grate than is necessary for the proper combustion of the coal.

At the time we first took up this subject there was a very great excess of air passing through the furnace. One of the noticeable effects upon checking down the draft was the fact that the heat of the furnace was felt much more by the firemen standing in front of the furnace doors. With a great excess of air passing through the furnaces, little heat was radiated out through the front doors and the air in the immediate vicinity of the firing floor was removed sometimes two or three times as rapidly as was the case after the dampers were closed down to pass the requisite amount of air. Another effect was that the paint on the firing doors, which formerly had been fairly cool so that fresh paint would remain for several weeks, now burned off in a couple of hours' firing, and the wooden handles on the doors were so charred and burned, that in order to keep any handles at all, a special extension had to be put on the door, thus putting the handle nearly 8 inches from the door itself. This should indicate to any observer who did not care to go deeply into the subject of CO_2 that there must be some decided advantage in this, since it was evident that the cooling action which was previously present could not be obtained except by a great loss of heat.

Obtaining Gas Samples

It became necessary to obtain in some way a continuous sample, or a number of regular analysis, of the gas passed in the course of the day in order to keep "tab" on the continuous performance of the furnace.

We decided upon the scheme of using a continuous sampling chamber which would draw a sample throughout the day and could at noon or in the evening be analyzed by any one of the fuel-gas analyzers on the market, and an accurate idea of what the day's run had been could thereby be obtained. For this purpose we used a five-gallon glass bottle, similar to those which are used in all of the modern drinking stands, which was hung in an iron frame from a hook on the back of the boiler setting, the bottle being suspended in an inverted position and fitted with a cork having two holes.

Through one of these openings a tube passed which was connected with the CO_2 collector pipe, and the other was fitted with a nozzle which would just permit five gallons of water to escape in the time during which the run was to be taken. The collector consisted of a 4-foot piece of pipe inserted through the boiler setting into the breeching, which was plugged at one end and had a number of ⅛-inch holes drilled along its length so that an average sample could be obtained from the gas, although we found, by drawing a number of samples, that no appreciable difference could be obtained in the analysis of the gas which was collected at different points just below the damper.

A number of experimenters have collected their gas by inserting pipes in the different points of travel of the gases through the boiler itself, some even inserting porcelain tubes in the combustion chamber and drawing their gas samples from this point; but I feel that this is poor practice, as there is no assurance that the gas collected in the combustion chamber has had sufficient chance to combine, especially with long-flame bituminous coals.

The effect of leaks in the boiler setting can make a marked difference in the value of the CO_2 obtained, as can be seen from the accompanying chart, which shows the result of the daily analysis on a number of boilers. It will be noted that at one point the CO_2 percentages fell off to a very marked degree. An investigation disclosed that the upper part of the boiler setting was in very poor condition, and upon this being remedied the percentage immediately rose to the value which should be obtained.

I have seen the statment that a good coat of red oxide paint upon a boiler setting will materially decrease the amount of air which can filter in through the setting. I have some doubts in regard to the value of this treatment, as this would really affect nothing but the brick itself, because the lime can slack off the surface of the joints or cracks and the paint which is on this would, therefore, fall off. Moreover, it would be a very porous joint indeed which would be benefited by sealing with paint. A boiler setting may be kept up to a good standard finish with a cheap coat of whitewash, and the slight amount of glue which can be added to the whitewash will give it binding power and probably have the same effect as a more expensive coat of linseed oil.

But after all is said and done, very little can be expected from the firemen if they are just told what is desired and the results demanded of them. The fact that the work is so much more difficult will make them unwilling to undertake to obtain the best possible results; and if the fireman's work is made more difficult, it is only right and proper that he should receive a corresponding increase in his earnings.

Bonus

The problem arose as to what degree of premium or bonus should be given for more competent work. Our means of solving this problem were empirical, as the question really resolved itself into how much premium was necessary to excite the firemen's cupidity to such an extent that they would always strive for the best results; but an approximate means of arriving at some result might be this: One man fires 10 tons of coal a day at a cost of $2.30 per ton. If the CO_2 is running at 5 per cent., the loss will be 30 per cent. of the fuel. This represents a loss of $6.90 per day. Giving the fireman 10 per cent. of this would be 69 cents. It might, however, prove advisable to offer a premium of 75 cents for 12 per cent. of CO_2. If you have 12 per cent. of CO_2 for a whole day's run, it means that you are going to obtain very much better results than this at certain periods, as there always occur lesser periods on account of cleaning fires, etc. Offering 75 cents for 12 per cent. of CO_2, we have the following premiums for lower rates:

CO_2	Premium
12 per cent.	$0.75
11½ "	0.70
11 "	0.65
10½ "	0.60
10 "	0.55
9½ "	0.50
9 "	0.45
8½ "	0.40
8 "	0.35
7½ "	0.30
7 "	0.25
6½ "	0.20
6 "	0.15

It is inadvisable to offer any premium for percentages above 12 per cent. This will mean that the higher percentages will be obtained by choking off the air necessary for the combustion of the furnace, and, as a consequence, more and more CO will be produced. As it is, there is a probability that 14 per cent. or even a little over will be produced at different times in order to bring up the average.

This premium system will work wonders, having a wonderfully stimulating effect upon the firemen, as may be seen by referring to the chart, where the effect of premium is immediately shown by the fact that the CO_2 at once advances to a point which we were previously not able to obtain.

Operation of System

In operating with this system it is the custom to attach the flue-gas collecting bottle, previously spoken of, at the beginning of the morning shift. At noon this is removed and the gas analyzed. The

same is repeated in the afternoon, and the average of the two samples indicates what premium should be paid that fireman. Each furnace is equipped with a separate collecting bottle, so that what each man receives depends upon his own individual efforts.

Operation of Stoker Furnaces

In regard to the operation of stoker furnaces, the problems which they present are rather different from that of a straight, flat grate in a hand-fired furnace. This is so because they are always equipped with a number of mechanical devices for feeding, handling the ash, etc., the result being that the entire firing surface of the furnace is never entirely covered with coal. In making this statement I am referring particularly to some of the chain-grate patterns. The underfeed stokers require that air be forced through the fuel bed for combustion and at the same time air is usually admitted at the sides. I do not know what sort of continuous results can be obtained with these furnaces. One trouble with the chain grate is, that an excess of air is permitted to flow in around the sides of the grate and especially at the inner end, where considerable clearance is required in the setting, in order to permit the cinders and clinkers, which are carried out by the grate, to pass below over the end of the ashpit.

In one case this clearance was originally ample, but was greatly increased by the abrading action of the cinders and clinkers in passing through, until the space was still further widened, and the loss by the passage of cold air very much increased. In fact, in the station I have in mind, the superintendent had been experimenting with a number of the different types of CO_2 recorders for some time, and despite his best efforts, I do not know that he ever obtained a continuous average of over 6½ per cent. CO_2. There is no doubt but that the mechanical stoker affords very decided advantages, such as smokeless combustion, etc., over hand firing, but in highly efficient regulation of the fires I doubt if it is as valuable as a good fireman.

Large Regenerator Plant at Youngstown

The Youngstown Sheet and Tube Company, Youngstown, O., has recently installed a 3000-kilowatt mixed-flow turbine plant. The exhaust steam of the reversing engine passes through a Rateau steam-regenerator equipment, which furnishes a steady supply of steam to the mixed-flow turbine.

The regenerator equipment includes three regenerators, 8x40 feet, which contain some 150 tons of water. The heat-storage capacity is sufficient to furnish steam at the rate of 90,000 pounds per hour for a period of three minutes, with variations of pressure not exceeding three pounds. This heat-storage device regulates the intermittence of the flux of steam, allowing the steam turbine to run up to its full-load capacity during the periods of light load or stoppage of the reversing engine, provided these periods do not exceed three minutes, which is the full-load time interval of the outfit.

When the mill engine delivers more steam than is required by the turbine, the temperature of the body of water is raised to a maximum temperature corresponding to a steam pressure of three pounds gage, thus creating a storage of heat for the periods during which the exhaust steam delivered by the reversing engine is not sufficient to take care of the turbine load. This Rateau steam-regenerator equipment is the third installed in America.

The first equipment was put in operation at the South Chicago works of the International Harvester Company. The regenerator was 11 feet 6 inches in diameter and 30 feet long, having a capacity of 55 tons of water, which was sufficient by actual test to deliver all the steam for a 50 per cent. load on the turbine for a period of 430 seconds, the turbine being rated at 500 kilowatts capacity. A complete description of this installation and of the tests conducted on the regenerator and turbine are given in the June, 1907, number of Power.

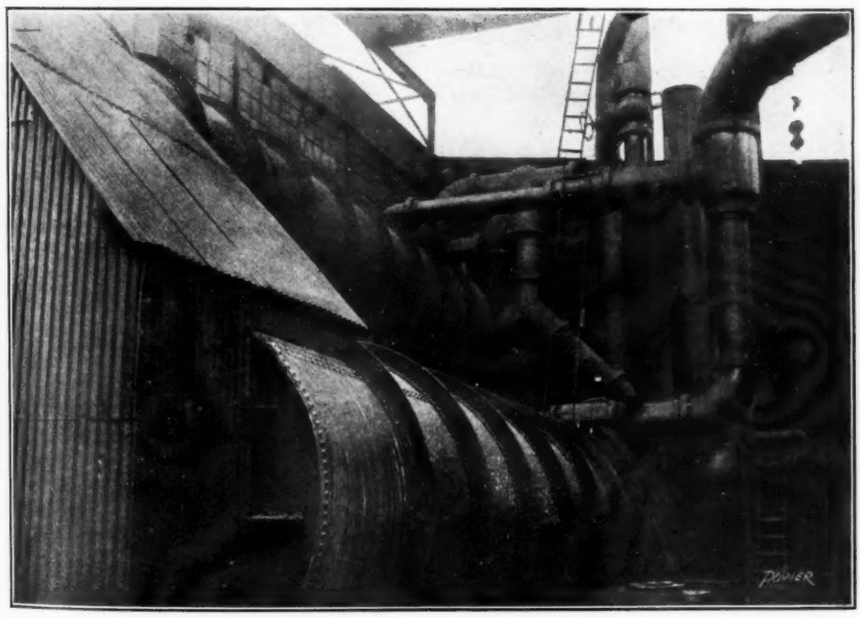


Fig. 1. Regenerator Plant at Youngstown

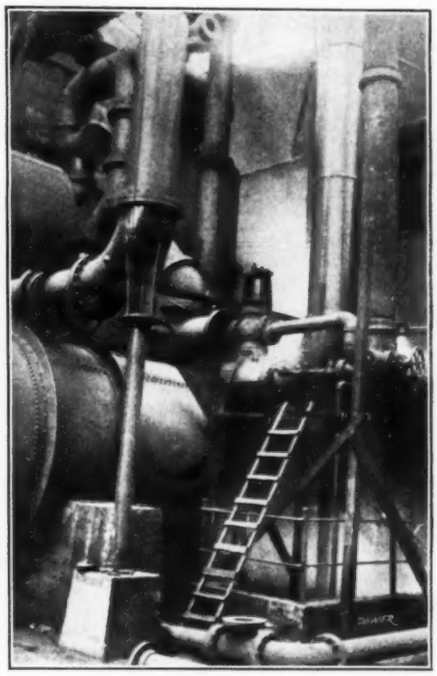


Fig. 2. Side View Showing Piping

A resident of New Tazewell, Tenn., claims to have solved the problem of perpetual motion and believes that he will have a perfected machine ready in a short time. He claims that the discovery is due to divine revelation, and that the discovery is not to be brought about for any man's personal gain, but for the good of humanity.

Vacuum Bottle and Rhode Island Coal

BY F. L. JOHNSON

"Once upon a time," said my young friend Sawyer as he walked unannounced into my presence the other day after several months absence, "there was a king who (like all kings regarding the conventionalities of royal life as being of paramount importance) kept a fool. One day this fool said, 'Sire, why is it that if a fish weighing a pound is put into a tub of water weighing 50 pounds the fish and water together will weigh no more than the water alone?'

" 'Really,' said the king, 'I do not know; a king is not obliged to know anything. He is a king because he is what he is and not because of what he does, but I have a college of wise men who have not been earning their salaries lately. Their jobs have been continuous vacations with full pay. Here is where they get on the job. Tell the chief of police to round up the bunch, trot them into the library and I will see them after lunch.

"When the savants were corralled and the king had finished his POWER AND THE ENGINEER perfecto, he propounded the fool's question. Following court-martial rules, the youngest was required to give his opinion first. He gave a long dissertation on the anatomy and physiology of fishes in general, dwelling minutely on the contractile and extensor muscles controlling the air bladder, and the effect the size of this bladder had on the specific gravity of the fish. Verbally he stepped on his own feet so often that becoming rattled he closed by saying that the law of gravitation was partially inoperative under water.

"Others gave opinions of varying degrees of stupidity, until the turn of the oldest came. He was a man in his dotage, bald, toothless and almost blind. For years he had done nothing but sit and think, and oftentimes he only sat, and he had been sneeringly dubbed by everyone who knew him, or knew of him, with the title of Old Wisdom. When it came his turn to give his opinion of the cause of the alleged phenomenon he said: 'Sire, before attempting a clarification of the heterogeneous concepts concerning the cause of this alleged marvel, I would first ascertain if the affirmation be true. Is the statement that there is no increase in the weight of the contents of the tub when the fish is added a statement of fact?' "

Sawyer stopped, and I, looking up, said, "That is a very pretty story about what?"

"Why, about the vacuum bottle to be sure. What else is there that the scintillating minds are wasting their coruscations on just now? Does it keep hot longer than it keeps cold and what is meant by hot or cold?"

"Well," said I, "there seems to be a little interest in Rhode Island coal just now. What do you know about that?"

Softly whistling a few bars from "I love my wife, but—Oh, her family," he looked about for a vacant chair, which he drew up to the desk. Getting comfortably seated he said: "Well, I ought to know a little about it for I used to live on Willow lane, in Portsmouth, before the mines closed in about 1870. Previous to this time the Taunton Copper Company used to import copper ore from South America, which was smelted with Rhode Island coal. That beneficent measure, the Republican tariff of 1870, put an end to copper smelting there, but considerable coal was mined and sent to Taunton, where it was used under the boilers for steam-making purposes. I remember the boilers quite well. There were two of them, one a two-flue affair and the other a plain cylinder, each about 32 inches in diameter and 30 feet long. Forced draft was used. There was a steam-jet arrangement which drove a small fan, which was supposed to draw in air and force it through the fuel. One of the fans went to pieces one day, and it was found that the steam jet forced more air without the fan than with it.

"In due course of time, Mr. Crocker, head of the Taunton Copper Company, died, and his successor not having the sentimental interest in the mines that had possessed Crocker, the mine was abandoned. During Mr. Crocker's life Rhode Island coal was sold to people living on the island for $4 a ton. Someone believing in the benefit of competition opened a coal yard near the mine, and offering Pennsylvania anthracite coal for $4.50 per ton soon had a monopoly of the coal trade on the island.

"Several attempts were made after Mr. Crocker's death to operate the mines, one of which was by A. B. Emmons, of the Rhode Island Land Improvement Company. In his efforts to interest capitalists in the mine he sent a lot of the coal to Haverhill, Mass., where an evaporative test was made at Saunders' shoe factory under the direction of the United States Geological Survey. An expert fireman was taken from the Newport torpedo-boat station to burn the coal under a water-tube boiler, a Root, I think, used exclusively for heating purposes. The boiler was fed by an injector, and all of the steam made was allowed to run to waste. If I remember correctly, the evaporation under actual conditions, making no allowances for anything, was about 6½ pounds of water per pound of coal, and the per cent. of ash was about 25.

"Under the boiler which furnished steam for the engine a mixture of Pictou coal and Pennsylvania anthracite screenings was burned. At about 11 o'clock one day, the expert started to fire Rhode Island coal under the power boiler. In about 10 minutes the steam pressure dropped five pounds and did not get back to the regular working pressure at all. At 11:30 more Rhode Island coal was put on the fire, and the steam dropped another five pounds, and at noon it was down fully 15 pounds. No further attempt was made to burn this coal under the power boiler, and I believe Mr. Emmons gave up the idea of putting the product of the mine on the market in competition with Nova Scotia or Pennsylvania coal. Afterward a man whose name I have forgotten started to make briquets of the coal, but he ran on to some kind of a snag and the briquetting machinery was taken back to Hoboken.

"At the mine today there is considerable activity. Money is being spent on the surface in buildings and machinery, as though a permanent industry was to be established.

"There is a steady demand for briquets for domestic purposes. These are sold in bags holding 19 pounds for 12 cents each, or $12.63 per ton, and on the bags there is an advertisement of Rhode Island coal, which gives the impression to a careless reader that the briquets are made of coal from the Portsmouth mines. Thus far in the present development there has been but little coal taken from the mines; one of the boys tells me eighteen skips of one-half ton or so each. It is easy to believe the statement that the coal is not to be offered for industrial purposes, as all the fuel seen about the boiler houses of either mine has the appearance of being Pocahontas.

"Something of the catalytic effect of the calcium chloride spoken of by Mr. Williams on the coal which was being burned in the station waiting-room stove must have taken place, for I saw what was claimed to be untreated coal giving off the long reddish-purple flames said to come only from the treated product. This effect must have been caused by the proximity of the tons of calcium chloride which I saw near the mouth of the south mine.

"As I sat in the station waiting for a train, someone who was apparently well acquainted with the agent said: 'Has that coal which you are burning been treated with anything to make it burn?' 'No,' he replied, 'I have burned both kinds and this treatment business is all

nonsense. The coal burns better without treatment of any kind than it does with it. Rhode Island coal has been burned ever since it was first discovered and long before treatment was thought of.' Someone had opened the damper and poked out the ashes at the bottom, and as I lifted the stove cover, I saw the long purplish-red flames swirling into the pipe."

He stopped for a moment, and I asked, "Is the coal any good; will it really burn?"

"Burn?" he replied, "Of course, it will burn. It will not only burn, but it will make elegant facing for foundry flasks; but whether it will burn in competition with Pennsylvania coal, even in briquets, I do not know. Operations have been going on for years, but since Samuel Crocker died no one has operated the mine for any length of time. I heard that Fitzgerald, who was mine superintendent in Mr. Crocker's time, had invested $1000 in the stock of the new company. This he most emphatically denies. I heard of other men who were well known on the island who were said to be interested, but I found none who were willing to admit it.

"Oh!" said he, "one little incident I forgot. A man by the name of Rice who owned a steel plant in Worcester shipped a lot of the coal to his mill, but did not continue the use of the coal for any great length of time. I suppose it did not pay."

Just here the editor of *The Engineering and Mining Journal* came in, and on learning that Mr. Sawyer came from Portsmouth he became interested, and we all went out to lunch.

Boiler Situation in Detroit

There is a movement on foot in Detroit to consolidate all the engineering societies into a united body for the purpose of securing intelligent and systematic action on questions affecting their welfare and that of the public. It is not intended that this consolidation should in any manner affect the individuality of the various organizations and is planned only to have some recognized head which can act with authority on questions upon which the different associations agree. This has been sadly lacking heretofore in the city of Detroit and should result in benefit not only to the engineering bodies themselves but also to the public in general. The associations affected would be Nos. 1 and 7 of the National Association of Stationary Engineers, No. 2 of the Universal Craftsman's Council of Engineers, No. 3 of the Marine Engineers Beneficial Association, No. 5 of the International Union of Steam Engineers and No. 346 of the Hoisting Engineers.

The question interesting engineers of Detroit at this time is that of boiler inspection, two different ordinances being now under consideration by the city council. The boiler question in Detroit starts from the disastrous explosion at the Journal building, some years ago, where thirty people were killed. Following this accident an ordinance was passed providing for city inspection and licensing of engineers. This ordinance was based largely upon that in force in Philadelphia at the time and proved satisfactory as a starter toward intelligent supervision of steam-generating apparatus. Among other things embraced in the ordinance, however, was a clause in section 18 to the effect that no person "Shall have charge of or operate a steam boiler in the city of Detroit without license"; and part of section 21 which provided that "Anyone who shall employ a person without a license to operate any boiler within the city of Detroit shall be deemed guilty of a misdemeanor and upon conviction shall be sentenced to pay fine not exceeding $1000 and to undergo imprisonment in the Detroit house of correction for a term not exceeding six months." The foregoing was enacted while the public mind was inflamed over the great loss of life and property and the ordinance was framed in a manner to indicate explosions could be stopped by placing engineers in charge of boilers for heating, power, etc., wholly neglecting to provide for first-class materials and workmanship.

When J. C. McCabe, the present chief boiler inspector, took office in August, 1908, enforcement of the ordinance then in effect brought such a howl from steam users, firemen, night watchmen, and others, on account of the above mentioned clauses that it became imperative to amend the ordinance and its revision has since then been a leading question.

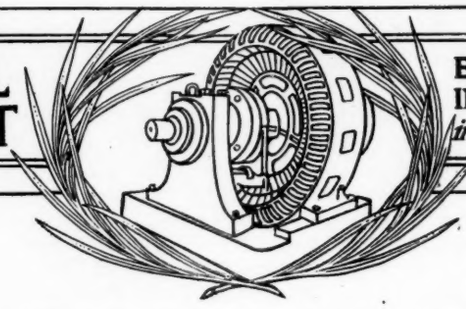
Of the two schemes proposed the Walsh ordinance is a copy of the revised Massachusetts rules in their entirety, which fixes a standard of workmanship and materials. This was submitted to the late convention of the American Boiler Manufacturers Association held at Detroit and approved by them. The other, or Knowlton ordinance, is also based largely upon the Massachusetts rules, the principal difference being in the factors of safety adopted. Adherents of the Knowlton ordinance, claiming the indorsement of the Manufacturers Association of Detroit, hold that a strict interpretation of the Massachusetts rules to the city of Detroit would condemn hundreds of boilers and impose unnecessary hardship on steam users, and that their ordinance has been framed to meet in the best possible manner the existing local conditions. In lieu of the Massachusetts rules, they provide a factor of safety of 4 for boilers carrying pressures not exceeding 100 pounds gage pressure per square inch; 4.5 for boilers carrying pressures not exceeding 125 pounds gage pressure per square inch; 5 for boilers carrying pressures not exceeding 150 pounds gage pressure per square inch, and 6 for all boilers carrying pressures from 150 pounds and not exceeding 200 pounds gage pressure per square inch.

Those advocating the Walsh ordinance point out that these factors of safety unduly favor old boilers which ought ordinarily to be progressively reduced in pressure according to age, and in addition to this, operate to the disadvantage of new installations. For instance, a boiler is cited at the plant of the Detroit Dry Dock Company, 37 years old and built of iron plates, the bursting pressure of which is calculated at 318 pounds. Under the present ordinance with a factor of 4.5, 70 pounds is allowed on the boiler. Under the Knowlton factor of 4, 79 pounds would be allowed, while according to the revised Massachusetts rules with a factor of 6 only 53 pounds could be carried. On the other hand, on 25 boilers at the plant of the Detroit Edison Company, with a bursting pressure of 1154 pounds, the Knowlton ordinance, using a factor of safety of 6, would allow 190 pounds boiler pressure, while the Massachusetts rules, using a factor of 4.5, give 254 pounds.

The present administration has collected a great number of interesting data in regard to the boilers installed in the city of Detroit. According to this list there are 1673 boilers in use, aggregating a total horsepower of 170,354. There are 271 boilers of unknown age, three of the oldest known being 37 years of age. It was discovered that one boiler, used for heating, had been in use for two years without a safety valve, and in completing the list, 700 boilers were found which had never been listed, nor had any regular examination. From the data collected it appears that 60 boilers aggregating 24,221 horsepower and ranging from one month to fourteen years of age would be reduced materially in pressure by the enforcement of the Knowlton ordinance, while the effect of the Massachusetts rules would be to reduce the pressure on a total of 67 boilers with a nominal horsepower of 7762, these boilers running between 19 and 37 years old.

The question is now being carefully considered by the city council and it is expected that a decision in regard to the rules will soon be made.

ELECTRICAL DEPARTMENT



ESPECIALLY CONDUCTED *to* BE *of* INTEREST *and* SERVICE *to the* MEN *in* CHARGE *of the* ELECTRICAL EQUIPMENT

The Electric Elevator

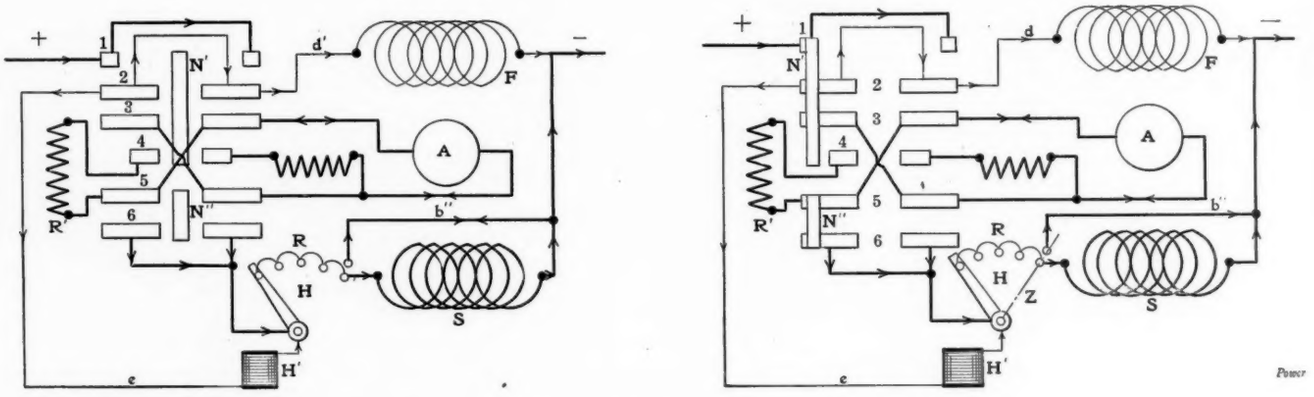
By William Baxter, Jr.

Dynamic Braking

The retarding action of an elevator motor when it is driven above the critical speed by a descending load is entirely automatic. If the load is light the motor will only speed up slightly, but if the load is heavy the motor will speed up more, the speed in any case being nearly proportional to the retarding effort required to hold the load. This same action of the motor is also made use of to develop a retarding effect to assist in stopping the elevator, and when so used is known as "dynamic braking." Elevators that are intended for slow speeds and are provided with simple controllers are stopped by means of a friction brake which in some cases is operated mechanically through a connection with the stop-motion mechanism and the operating sheave, and in other cases by means of an electromagnet, all of which has been fully explained in connection with the description of the Haughton and the Otis elevators.

Dynamic braking can be effected in two ways, in one of which the retardation is of short duration and not very great, and in the other the retardation can be made as great as desired and to continue for any length of time that may be necessary. The first method can be better explained in connection with the diagrams, Figs. 89 to 92. These diagrams represent the windings of a compound-wound motor and a reversing starting switch on the left. The motor armature is indicated at *A*, the shunt-field winding at *F* and the series-field winding at *S*. The starting resistance *R* is cut out automatically by the switch *H* operated by a magnet *H'*. The contacts of the starting switch are all stationary except *N'* and *N''*, and these when in the central position, as in Fig. 89, disconnect the motor from the line and when moved to the extreme left-hand position, as in Fig. 90, connect the motor with the line for one direction of rotation, and when moved to the extreme right-hand position connect it for the opposite direction of rotation. When it is desired to stop the motor the contacts *N' N''* are not moved back from the position of Fig. 90 to that of 89, but to the intermediate position shown in Fig. 91. The connections effected in this position are more clearly shown in the simplified diagram Fig. 92, which shows only those starting-switch contacts that complete the connections in Fig. 91. When the movable contacts are moved to this intermediate position, *N'* slides on the contact 4 and then the resistance *R'* is connected in series with the armature.

As will be noticed, *N'* is disconnected from the contact 1 so that the motor is disconnected from the line, but as may be seen in Fig. 92, if the armature is generating a current it can flow through the wire *d'* to the shunt field coil and keep the motor field magnetized. As explained in a previous article, if the motor is run-



Figs. 89 and 90. Diagrams of Connections for Friction and Dynamic Braking

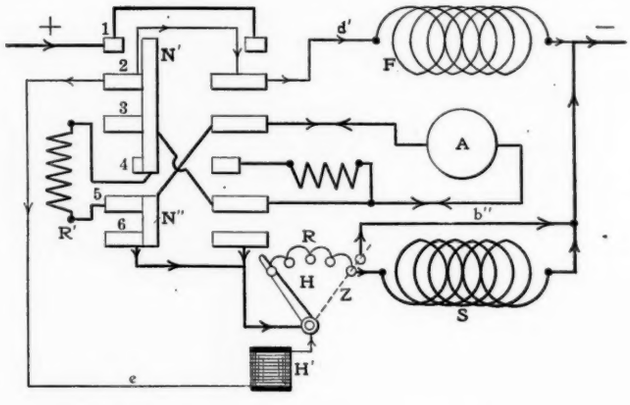


Fig. 91. Dynamic Braking Conditions

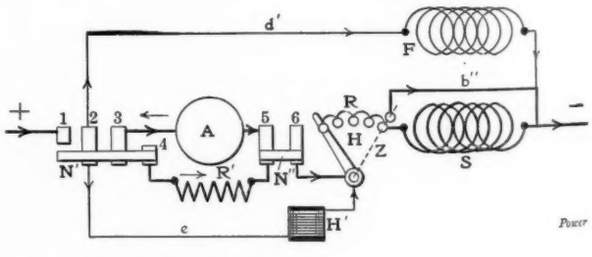
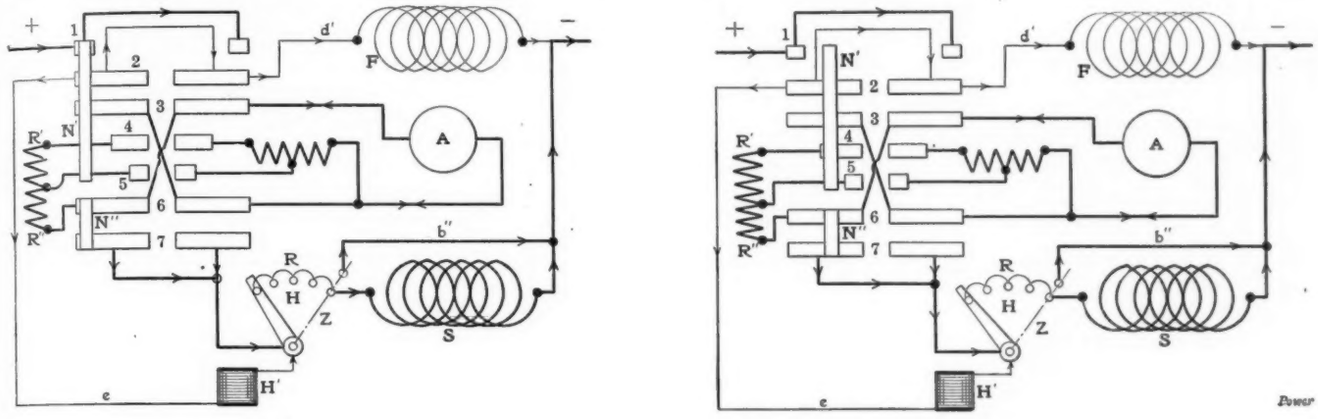


Fig. 92. Simplified Diagram of the Active Circuits in Fig. 91

ning above the critical speed the current generated will be of high enough voltage to send a current through the shunt field that is strong enough to keep it magnetized to the strength necessary to cause the machine to continue to generate; but if the speed is below the critical point, it will not, and then the armature current will soon die out. As long as the armature generates an e.m.f., a current will flow through the resistance R' as indicated by the arrows in Fig. 92, and a retarding effort will be developed thereby. If R' is of high resistance, the current passing will be small, and the retardation also small; but if R' is of low resistance the current will be strong and the retardation great. By properly proportioning the resistance of R' the retardation can be made anything desired.

Suppose the elevator is running down with a heavy load, and that the switch is moved back to the position of Figs. 91 and 92, to stop the car. As the load is driving the motor, it will be running above the critical speed, and the armature will generate a strong current that will develop a retarding effort which will soon reduce the speed; but when the critical speed is reached, the armature current will reduce and soon a point will be reached below which the speed will not



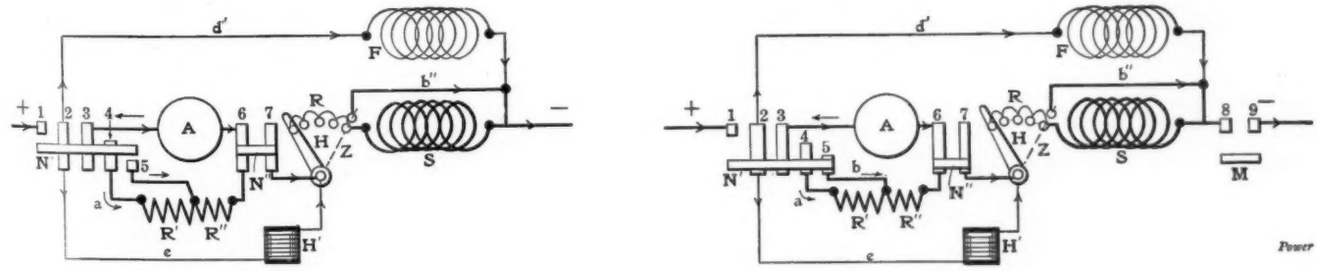
FIGS. 93 AND 94. CIRCUIT CONNECTIONS FOR GRADED DYNAMIC BRAKING

tardation due to dynamic braking will be greatly reduced, because of the rapidly declining magnetism of the field. If the current flowing through wire d' were stopped the instant the motor speed is reduced to the critical point, the field magnetism would die out almost immediately, and the assistance of the dynamic brake after this instant would be trifling; but as current flows through d' and the field winding as long as the armature generates it, the magnetism does not die out so rapidly, hence the dynamic braking lasts until the motor comes to an actual stop, although it is very small after the speed has fallen much below the critical point.

When the switch is first moved to the position of Fig. 91, the dynamic braking is very strong, and reduces gradually as the motor slows down, but the combined effect of the friction and dynamic brakes is much greater than that of the friction brake alone. If the motor is lifting a heavy load when the switch is moved to the position of Fig. 91, the dynamic-brake effect will be weak at first because the motor will be running below the critical speed and will not generate a strong current. This, however, is just what is desired, because when the motor is lifting the load, the additional retarding effort required to stop is small; the load itself drop, unless some additional influence is introduced. If at this instant the friction brake is applied, then the motion of the elevator will be retarded by the combined action of the friction brake and the dynamic brake. As soon as the speed is reduced below the critical point, the reacts to stop the car. When the load is driving the motor, however, the retardation must be great because the load tends to keep the car running.

To prevent any violent reduction in car speed that might be experienced if the current flowing through the dynamic-brake circuit is very strong when it is first closed, the resistance R' is sometimes made in two or more sections, so that when the circuit is first closed the resistance is high enough to keep the current strength within reasonable limits, and the sections of this resistance are then cut out one after the other as fast as may be necessary to obtain the desired retarding effect. The diagrams Figs. 93 to 96 show an arrangement of this kind in which the resistance in the braking circuit is made in two sections, R' and R'', and these are arranged so that both are in the circuit at the start, and at the proper time one of them is cut out. To accomplish this result the starting switch or controller is made so as to move through two intermediate steps in stopping, the first one connecting the contact N' with the contact 4, so as to cut into the circuit the two sections of the resistance R' and R''. On the second intermediate step N' connects with the contact 5 and cuts out the resistance R'. The two intermediate stopping steps are shown clearly in the simplified diagrams Figs. 95 and 96.

When the friction brake is actuated by a magnet it is arranged so that the magnet acts to hold the brake inactive, a weight or a spring being provided to put the brake on. This arrangement is used as a safety device, so that if for any reason the current fails to pass through the brake magnet, the brake will not be released and the elevator will not start, or if running it will be stopped. The way in which the magnet is connected in



FIGS. 95 AND 96. SIMPLIFIED DIAGRAMS OF THE ACTIVE PARTS OF FIGS. 93 AND 94

the circuit is shown in Fig. 97, where the brake magnet is shown at *M*. The magnet is disconnected not only from the line but also from the motor circuit in stopping. It would not do to leave it connected with the motor circuit, as shown in Fig. 98, because then if the elevator were driving the motor, the current generated in the armature would flow through the brake magnet as shown by the arrows and would prevent the brake from going into action, the result being that the car would continue to run to the top of the elevator well. If the motor were arranged with a dynamic-brake circuit as at *B* in Fig. 99, the car could not attain a dangerous speed because the current that would flow through the low resistance of the dynamic-brake circuit would be great, hence the motor could not speed up dangerously. Without the dynamic-brake circuit, however, the motor would speed up rapidly, because the current delivered to the magnet of the friction brake would hold that brake off, and the dynamic braking effect of the current passing through the shunt-field winding and both magnets would not be sufficient to keep the motor from speeding up.

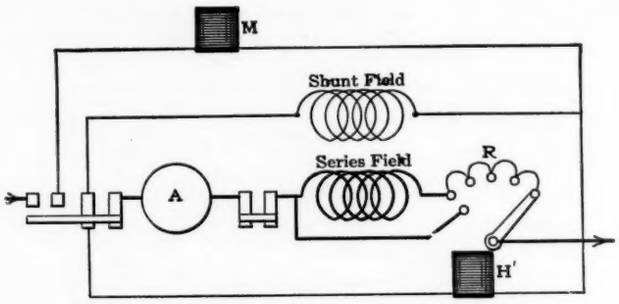


FIG. 97. CORRECT CONNECTIONS FOR THE FRICTION-BRAKE MAGNET

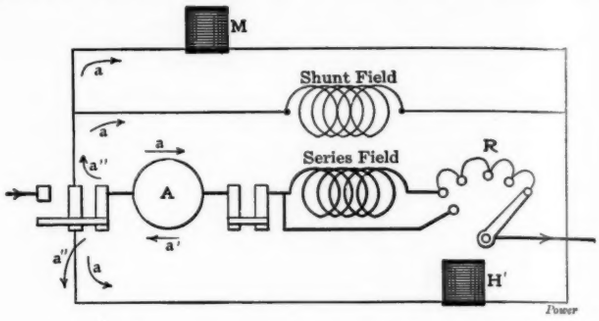
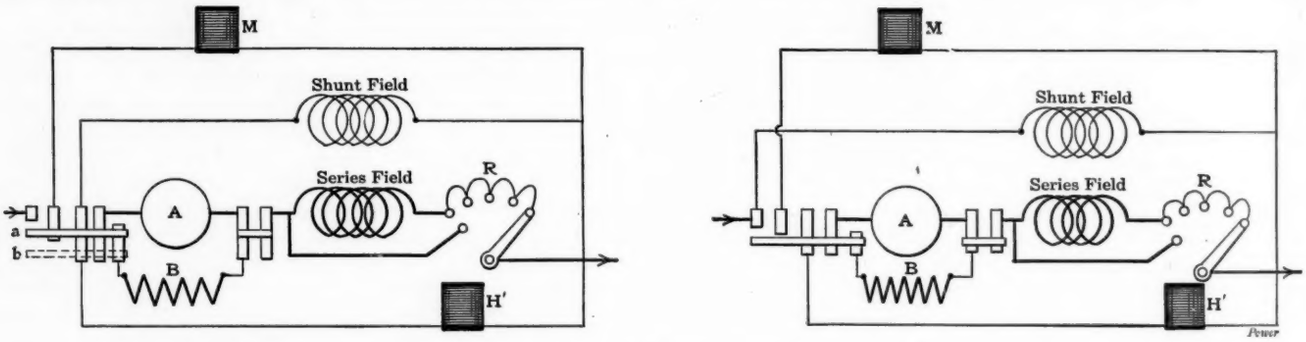


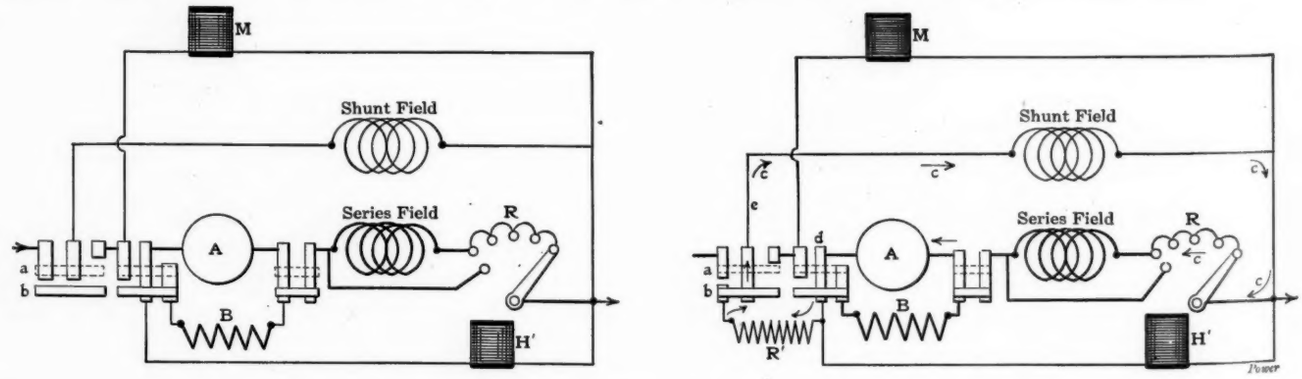
FIG. 98. INCORRECT CONNECTIONS FOR THE FRICTION-BRAKE MAGNET

When a dynamic brake is used the controller is generally made so that the dynamic-brake circuit is closed at the instant that the line connection is broken, as indicated in Fig. 99, but the brake-magnet circuit is kept closed until the controller is moved one step further, that is, until the movable contact is advanced to the position *b*. In this way the dynamic brake is made to act alone so long as the movable contact remains in the position *a*, and both brakes act together after the contact is moved to the position *b*.

In the dynamic braking arrangements just considered the retarding action is strong at the start but gradually reduces to nothing as the motor speed declines, because the e.m.f. generated by the armature is due to the magnetism induced in the field by the current that is produced by the armature e.m.f., and this e.m.f. gradually reduces to nothing as the motor slows down to a stop. The dynamic brake is also arranged so that when the motor is disconnected from the line the shunt-field winding is not, and in this arrangement the retarding action can be made much stronger, and can be kept up until the motor actually stops rotating, because the field strength does not decrease with the motor speed. The connections for this arrangement are shown in Fig. 100. The objection to the arrangement is that while the motor is stopped, current still flows through the field winding and power is being consumed. This objection is sometimes overcome by connecting the field in



FIGS. 99 AND 100. SIMPLIFIED CIRCUIT DIAGRAMS OF MOTOR WITH COMBINED FRICTION AND DYNAMIC BRAKES



FIGS. 101 AND 102. CONNECTIONS FOR DYNAMIC BRAKING WITH FULL FIELD STRENGTH

the way shown in Fig. 101, in which the first movement of the controller disconnects the motor armature from the line, and the second movement opens the circuit through the shunt-field winding; second movement is made just before the motor stops. When the controller is moved to the second step, that is, to the position *b*, the opening of the shunt-field circuit causes a serious flashing at the switch contacts, and also causes a field discharge which tends to break down the field-coil insulation, as fully explained in previous articles. To prevent these actions, the connections are sometimes modified in the way shown in Fig. 102, in which a high resistance *R'* is introduced so as to form a discharge circuit for the field coils at the instant that the connection with the line is broken. As will be seen in the diagram, when the controller is in the position *a* the field winding is connected with the line, but when the position *b* is reached and the line connection is broken, the circuit through *R'* is closed.

CORRESPONDENCE

Locating Insulation Faults in Electric Circuits

Under this heading Mr. Ryan gave some very interesting information in the December 14 issue, but perhaps some further thoughts along this line will not go amiss.

By Mr. Ryan's method we may determine if the insulation is at fault; but to locate the fault is another proposition. This is easily done by means of a slide-wire bridge; but where there is none at hand the same method may be employed by means of improvised apparatus. Take a pine board about 1x3x27 inches; set a small binding post near each end, so the two will be just 25 inches apart. Connect them together by means of a resistance wire drawn taut. See Fig. 1. Get a galvanometer, about three dry battery cells, and a few feet of copper wire and you are ready to begin operations.

Fig. 2 shows diagrammatically how the apparatus is connected up: *R* is the resistance wire; *A* and *B* are the line wires to be tested, which are connected together at their distant ends, as at *D*, and *G* is the ground to be tested for. The battery cells are connected between the earth and a sliding contact *C* which is applied to resistance wire at any point. This slider is moved along the wire until the galvanometer shows no deflection. The current then flows from the battery to the point of contact *p*, where it divides, one part flowing through *A*, *D* and *B'* to *G*, and the other half through *B* to *G*, the two currents uniting at *G* and returning through the earth to the battery. When the galvanometer shows no deflection, that indicates that the potential is equal at its terminals, and for this to be true, the relation between the resistance of the wire *R* from *p* to *a* and that from *p* to *b* must be exactly the same as the relation between the resistance of the line wires from *a*, through *D*, to *G* and that from *b* to *G*. That is, if the resistance from *p* to *a* is twice that from *p* to *b*, then the resistance from *a* to *G* will be twice that from *b* to *G*.

Now it is not necessary to find the actual resistances, because they are proportional to the lengths of wire, both in the line and in the resistance wire *R*. Therefore the comparison may be made directly in distances. Divide the distance from *a* to *p* by the distance from *p* to *b;* the result will be equal to the distance from *a* to *G* divided by the distance from *b* to *G*. But, of course, the distance from *b* to *G* is not known; it is that that the test is to determine. However, the distance to *D* is known, and it does not take much calculation to find out the proportion of that distance which lies between *D* and *G*.

Divide the distance from *p* to *b* (the shorter length of wire) by the distance from *p* to *a*, and call the result *K*. Represent the length of the wire *A* by the same letter and the unknown distance from *b* to *G* by the letter *B*. Then

$$\frac{1-K}{1+K} \times A = B$$

For example, if the resistance wire *R* is 25 inches long and the galvanometer balances when the slider *C* is 15 inches from *a*, then

$$K = \tfrac{10}{15} = \tfrac{2}{3}$$

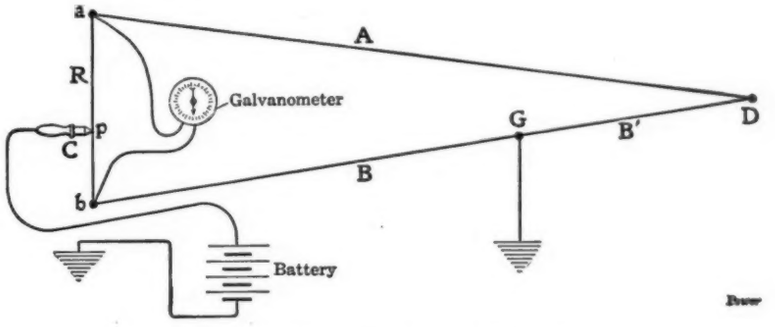


FIG. 2. CONNECTIONS FOR TESTING

If the length of the line *A* is 6 miles, then the distance from the point of testing to the ground on the line wire *B* will be

$$\frac{1-\frac{2}{3}}{1+\frac{2}{3}} \times 6 = 1.2 \text{ miles}$$

J. M. ROW.

Fort Monroe, Va.

[The method described by Mr. Row is the Murray "loop" test, which has been used many years in testing cables. To get accurate results the test should be made twice, once with the negative battery terminal to ground and once with it reversed.—EDITOR.]

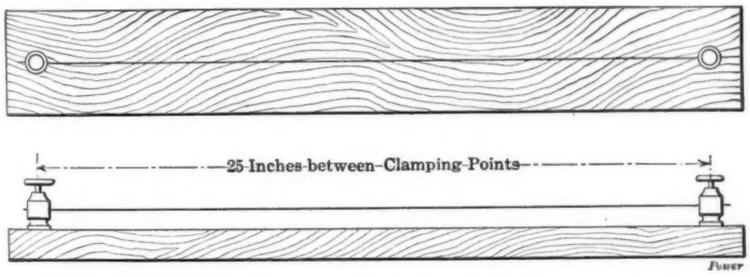


FIG. 1. A HOMEMADE SLIDE WIRE BRIDGE

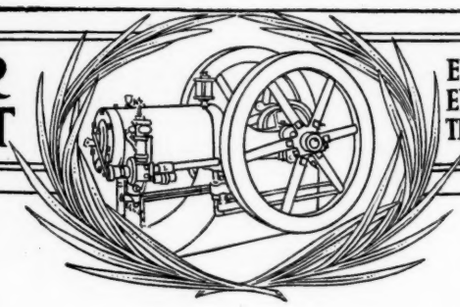
Thawing a Frozen Water Pipe

This winter I was called on to thaw out an underground water pipe, 1½ inches in diameter and about 400 feet long. There was a 1¼-inch steam pipe which ran close to the far end of the water pipe, and after shutting-down time I disconnected the steam pipe in the boiler room and connected it and water pipe together at the far end with No. 00 copper wire. I then connected one terminal of a 500-volt generator with the steam pipe and the other terminal to a water pipe which connected with the one that was frozen. I put a heavy shunt on the series field winding of the generator and cut in resistance in the shunt field circuit so as to get a low voltage. With 55 volts we got a current of 400 amperes, and the pipe thawed out entirely in two hours. The pipe was ordinary galvanized pipe.

F. W. REED.

Havre, Mont.

GAS POWER DEPARTMENT



EVERY THING WORTH WHILE *in the* GAS ENGINE *and* PRODUCER INDUSTRY WILL BE TREATED HERE *for the* USE *of* PRACTICAL MEN

Composite Power Generation

By J. M. W. Kitchen

A study of the subject of power generation soon brings one to the very definite conclusion that there is no type of power generator suitable for all cases in which motive power is required. The necessity of adaptability to special requirements must first of all be recognized. Each type of power generator has its virtues, and also its defects and limitations. A gasolene engine, for example, is so adaptable and so easily applied to light work that it is widely used without regard to the cost of the fuel. If liquid fuels of a sufficiently low cost were only available, the internal-combustion engine using such fuel would be almost universally used, even in connection with heating processes.

For stationary engines there is nothing more cleanly and convenient than to use a prepared gas of definite and uniform quality; and when it was found that the very cheap producer gas was a splendid fuel for the gas engine, there was a widespread assumption that the use of producer gas would quickly become almost universal. As a matter of fact, comparatively slow progress is being made in the adoption of producer gas for power generation; and that progress is only being made along certain special lines. In view of the extraordinary difference in the fuel cost of power, as generated in the steam plant and in the internal-combustion engine, there must be many who have wondered why this new power is being adopted so slowly.

There are many reasons why producer-gas power is not making more rapid progress. Among these reasons may be cited the following:

1. Gas power is relatively new, and few people understand it yet.

2. Prepared gas of uniform quality is still sold at too high a price; but this obstacle will gradually disappear. A sufficiently good fuel gas for general purposes can be made for about 15 cents per 1000 feet and sold at a good profit at so low a figure that an enormous consumption of it in gas-engine work could be expected.

3. The making of the cheaper producer gas of lower heat value is an art that is somewhat difficult to acquire and practise, and there are as yet in this country very few who are skilled in this art. The gas is made "in the dark," as it were, and the difficulty of continuous production of gas of the right quality and quantity, through the use only of the trained touch and of mere abstract judgment, without the aid of the eye, seems to me to be the greatest real obstacle to the use of this power. Still, the art of making this gas is readily acquired by individuals of fair intelligence. Anyone who can manage an automobile properly ought to be able to successfully attend a producer-gas installation. When it is understood that the possession of such knowledge brings better pay to the possessor, and entails a smaller degree of physical discomfort than ordinary steam-power production, there will be abundance of labor offered to this field.

4. Gas-producing and cleaning devices have been somewhat crude and undeveloped. This obstacle is already being removed by evolutionary work in the mechanical world.

5. The producer-gas engine, requiring as it does the use of very high compression, is difficult to start and must be carefully watched as to its rate of speed, as affected by the load carried, to keep its motor activity unimpaired. A little variation in the quality and quantity of gas fed to the engine may, and frequently does, cause trouble. In the normal production of the gas these variations are continually occurring, and when they do occur, the attendant in charge has immediately a guessing problem to solve as to the reason for the trouble. To be on the safe side, a considerable margin must be provided in ability of the engine above that which is necessary to carry the load, and this means unnecessary first cost and operating expense.

6. Hitherto, adequate provision has not been made to successfully use as cheap a fuel as can be used in steam-power generation, but this obstacle will be soon overcome; in a future article it will be shown that fuel of a character that cannot be used in steam generation can be used successfully in the internally fired gas producer.

7. The larger initial cost of installing gas power has unquestionably had considerable influence in retarding its adoption; but a little study of the question will make it plain that as a mere economizing practice, the adoption of gas power will pay very large dividends on the extra cost of installation in most instances.

8. The most prominent reason evident for the restricted use of gas power is that usually exhaust steam is a convenient source of heat for heating purposes, and that such use is considered a great economy, while it has not been thought practical to use the waste heat of the gas engine for heating purposes. This reason is sound so far as depending entirely upon such heat wastes for heating purposes is concerned; for when fuel is not burned in the gas engine no heat is available for heating. Nevertheless, it is practical to utilize such waste heat for heating, so far as it is produced. The exhaust heat of the jacket water and exhaust gases of the gas engine is of relatively low intensity, and cannot be concentrated after its diffusion except at a cost that is uneconomic; but this diffused heat can be used for heating purposes if right means for using it are adopted. It should not be forgotten, though, that producer gas is very low in heat value, and although a splendid fuel for power generation, is of relatively low value for heating. Almost every gas-power plant must use an auxiliary heat-generating means for providing high sensible heat to meet cold-weather conditions. So far as direct heating is concerned, it is less expensive to generate the heat by the direct complete combustion of fuel and it is relatively as practicable to secure perfect combustion and transmission of such directly generated heat as it is to generate it through the agency of a gas producer and an internal-combustion engine.

The steam boiler and the steam engine are not going to be entirely laid on the shelf in the future, especially when steam heating is the principal object. The gas engine will not displace the steam engine when small amounts of power are needed along with much heat for heating.

Nevertheless, when it is realized how splendid a combination, with a large field of usefulness, can be made by the composite generation and application of steam and gas power, the latter source of power should be widely used; the central fuel-gas and electric-generating plant with fuel-gas distribution and electric transmission of power will be the rule, and the individual power-generating plant the exception.

The following reasons seem to me to be conclusively in favor of the widespread composite use of steam and gas power:

1. Because of the fact that although

producer gas is a wonderfully cheap source of power, it has decided defects and limitations in application. The very intensity of its explosive force is in some respects disadvantageous. It is difficult to initiate motion in a gas engine, and it starts without moderation as to motion. There is only one power impulse in four strokes, the other three strokes absorbing power from the one; this necessitates a large number of cylinders for any approach to uniform torque, or else double-acting construction, which involves cooling difficulties.

2. Because steam is more flexible and more easily controlled and made to give wider ranges of speed.

3. Because steam is conveniently applicable for heating in quantity and in a manner more readily adjustable to varying climatic conditions.

4. Because by combining the two forces we get the utilitarian advantages of both with a fuel economy beyond that of either alone.

5. Because it is desirable in a gas-power plant to have an auxiliary means of initiating motion and for operating the various motor devices of such plants, separate and apart from motion of the prime mover.

6. Because, in a combined power and heating system, it is not necessary to have a separate source of heat when the composite system is used.

7. Because nearly all of the present heat wastes of gas power can be utilized in the creation of steam for power and heating.

8. Because steam is needed in connection with the generation of producer gas, and should be specially generated for that purpose to secure certainty as to the quality of the gas and the rate of production.

9. Because the steam power will insure smoothness in operation during unexpected and sudden drops in the rate of gas generation and changes in the quality produced.

With the editor's permission, I will, in a later article, describe a system for composite power generation covering the various problems involved.

A barge load of kegs of nails sank recently in the Mississippi river near New Orleans, and the cargo was raised, a few kegs at a time, by means of a huge electromagnet and a derrick. The barge was presumably wrecked, leaving the kegs free to be "grappled" by the magnet. The latter was of the usual iron-clad type used for lifting purposes; it was 3½ feet in diameter and weighed 3000 pounds. Such magnets have long been used in large steel mills and steel-working plants for lifting billets, sheets and other shapes of iron and steel, but this, we believe, is the first attempt to utilize them in marine salvage.

Fuels for Gas Engines*

By Dr. Charles E. Lucke†

All early gas engines were operated on illuminating gas and their use was consequently confined to cities where such gas was available, and the sizes that could be economically operated were limited also, because this kind of fuel is very expensive. To illustrate this latter point, assume that illuminating gas is sold at $1 per 1000 cubic feet, each cubic foot yielding on combustion 600 heat units. Under these conditions the purchaser receives for his dollar 600,000 heat units. Compare this with bituminous coal at $3 per ton of 2000 pounds, each pound yielding about 15,000 heat units, thus giving to the purchaser 30,000,000 heat units for $3 or 10,000,000 for one dollar. Under these conditions gas fuel is nearly seventeen times as costly as coal, so that power users could not afford to use such gas in competition with this coal unless a gas engine were capable of transforming into work about seventeen times as much of the heat in the gas as a steam-power system can convert of the heat in the coal. Enormous as this difference may seem, fully this much exists when the units are very small, a few horsepower, for example, so that in installations requiring only a few horsepower it is more economical to use a small gas engine, even with the expensive fuel, than to use the same size of steam engine with the cheaper fuel. When, however, the size of the unit increases to several hundred horsepower the situation is quite different. In these sizes illuminating gas as fuel can never compete with coal used directly.

If other and cheaper sources of gas supply or means of adapting coal and oil fuels for the use of gas engines had not been developed, the gas system of power generation could never have competed with steam in the larger sizes. In the development of the gas-engine mechanism up to the time when it had been demonstrated that it was a commercial machine, two sources of cheaper gas appeared. The first was the natural gas which issues from the earth, in only a few localities, the most notable of which are the middle central States, Pennsylvania, Ohio, Illinois, Indiana and West Virginia. This fuel is ideal and in some places can be produced and sold at a rate as low as five cents per 1000 cubic feet. As this gas yields about 1000 heat units per cubic foot, this price is equivalent to five cents per 1,000,000 heat units, or 20,000,000 heat units for $1.

The other source of cheap gas supply is the blast furnace, in which iron ore is converted into pig iron. To these furnaces, which are almost the same in general character as tall chimneys, alternate layers of coke, iron ore and limestone in measured quantities are fed at the top; the coke is ignited, heated air is blown into the bottom, and the whole interior becomes a white-hot mass. The heat permits the limestone to combine with the rock portion of the iron ore, setting free metallic iron. From the top of the furnace there is discharged a rather poor quality of combustible gas, which is mixed with the nitrogen from the air of combustion. The combustible gas is principally carbon monoxide, which is the result of combining one particle of carbon with one particle of oxygen; about 30 per cent. of the blast-furnace gas is combustible, the remaining portion being nitrogen. This combustible gas has always been used as a fuel for boilers, and when the gas engine

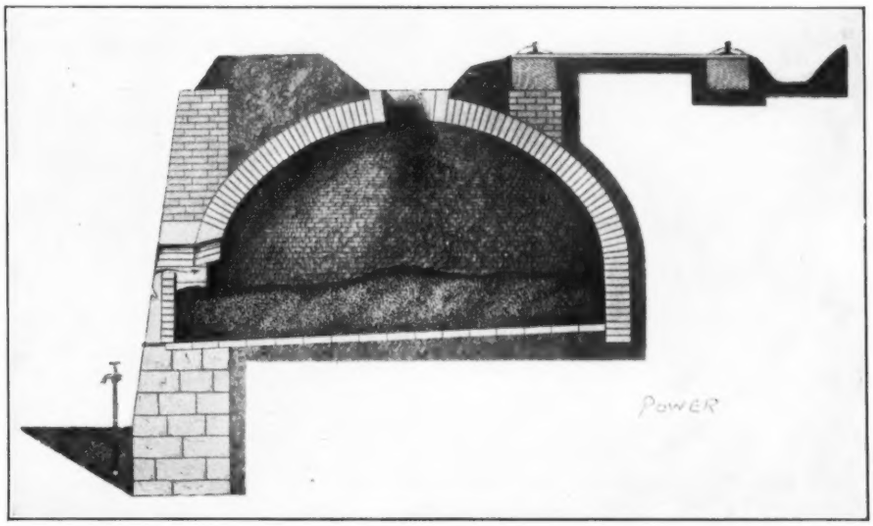


Fig. 1. A Beehive Coke Oven

*Part of the sixth Hewitt lecture, delivered on March 14 at Cooper Union.

†Professor of mechanical engineering at Columbia University.

developed, the gas was burnt directly in its cylinders, yielding twice as much power as before.

The really important developments, however, were not possible without the adaptation of the natural fuels, oil and coal. To understand the apparatus by which coal and oil are rendered available as a fuel for gas engines, requires first an understanding of the peculiarities of the fuels themselves. Perhaps the earliest attempts to get a combustible gas from coal were by the roasting processes, of which there are two important classes, one in which it is the gas that is driven off by roasting that is wanted and the other in which it is the residue or coke that is wanted.

In the making of coke from bituminous coal the standard method for a great many years has been to put a layer of crushed material in the bottom of a circular chamber, having an arched roof and more or less resembling a beehive, as shown in Fig. 1, and so called a beehive oven. This coal is ignited from the top and side and air is allowed to enter slowly. The heat for driving off the gas which the coal can yield by the roasting process is derived from slowly burning the gas in the upper part of the dome-like chamber until the whole bed has been equally roasted. In these beehive ovens the flame and burnt gases escape from the top through a hole. The coke which is left, and which weighs about 50 per cent. or 60 per cent. of the original coal, is drawn out and used in blast furnaces where coke is needed, but in the formation of the coke a peculiar thing happens. At a certain stage of the heating the whole mass may be said to be practically melted, each small particle of the original coal entirely losing its identity and merging with the rest, much the same as broken molasses candy will melt together in hot weather. From the molten mass the continuous escape of the gas punctures it full of holes, and after the gas is all driven off, the rest of the mass solidifies into hard, porous coke. It would be a single piece if the mass did not shrink in the process, but it does shrink, producing a series of fissures or cracks so that the coke consists of large pieces, sometimes as large as a man's body, but generally smaller, bearing no resemblance whatever to the original shape or size of the particles of coal from which it was made. This beehive oven method of roasting coal produces combustible gas which is allowed to go to waste, only a part of it being burned to maintain the temperature for the rest of the process. Here gas is the waste material and coke the desired product.

An almost exactly similar process of roasting is carried out in the manufacture of one kind of illuminating gas, in which gas is the desired product and the coke the waste product. In this system coal is fed to earthenware chambers open at one end and closed at the other, called retorts. Fig. 2 shows a group of nine such retorts in the same brick setting, with a coal fire maintained below to heat them from the outside. The heat from the lower coal fire roasts the coal in the retorts, driving off the gas, which is caught, purified and finally pumped through pipes under the streets of cities for illuminating and other purposes. After the roasting has proceeded for a time sufficient to drive off all the gas, the coke that is left is drawn out and sold.

In these coal-roasting processes there is driven off from the coke what we are pleased to call gas. It is, however, a most complex mixture of things, consisting of various compounds of carbon, hydrogen, oxygen and nitrogen with occasionally some sulphur. As carbon and hydrogen are the main fuel constituents it is very common to regard all of these substances as hydrocarbons and these hydrocarbons are all in the gaseous form when driven off because they are very hot at that time. When they are cooled, however, some of them will condense into viscous or thick liquids of bad smell and black in color. These are called by the general names of "gas tar," "coal tar," or just "tar" and it is this tar which is responsible for the melting down in the beehive oven or gas retort.

The gasification of coal for gas-engine purposes should leave no byproducts. All the coal should be converted into gas, so that mere roasting is not sufficient, for even though it yields a gas there is coke left over and means must be found for gasifying this coke. This involves the chemical combination of the carbon, which is the main constituent of both these fuels, with oxygen contained in the air.

When air is supplied to a fire of coke or anthracite coal it is believed that one particle of carbon will combine with two particles of oxygen of the air, the nitrogen being carried along inactive and neutral, so that the resulting gas, called carbon dioxide or CO_2, which is incombustible, is called the product of "complete combustion" of carbon and oxygen. If this particle of carbon dioxide or one particle of carbon and two particles of oxygen combined, be passed through more hot coke or carbon, then a further reaction is believed to take place. Another particle of carbon will be taken up, making two particles of carbon monoxide, in which one particle of carbon is combined with one particle of oxygen and which is combustible because it is capable of taking another particle of oxygen if it is available. To carry out this double chemical reaction air is supplied to a very thick bed of fuel, from 3 to 5 feet thick, and there is produced a combustible gas. All the coke or fixed carbon is consumed, and this, together with the roasting process, constitutes the means for changing any kind of coal completely into combustible gas with no residue and no byproducts. The apparatus in which these double processes are carried out is called a gas producer, and by the invention of gas producers also solid fuels become available for gas engines.

[The second half of Doctor Lucke's lecture, in which he explains the principles of the different types of modern gas producers, will appear next week.—EDITOR.]

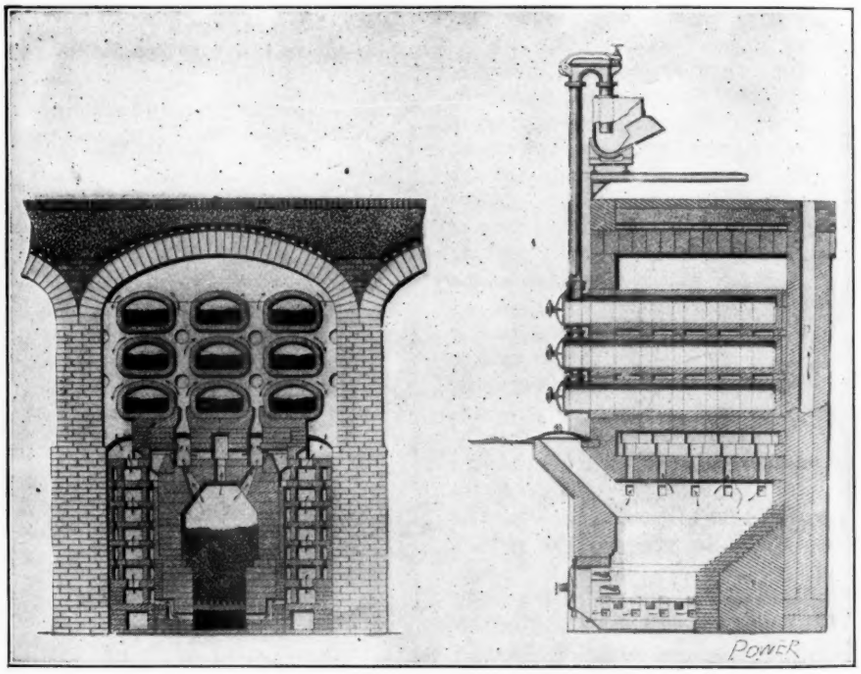


FIG. 2. A "BENCH" OF GAS-MAKING RETORTS

A New Type of Two-stroke Engine

The accompanying engravings, for which we are indebted to *The Engineer*, of London, illustrate the construction of a double-acting valveless experimental engine recently built by an English manufacturer. A feature of the engine which differentiates it from the familiar three-port type used on automobiles is that the crank case is not utilized as a compression chamber.

The cylinder of the engine is extended at the upper end to form a pump cylinder.

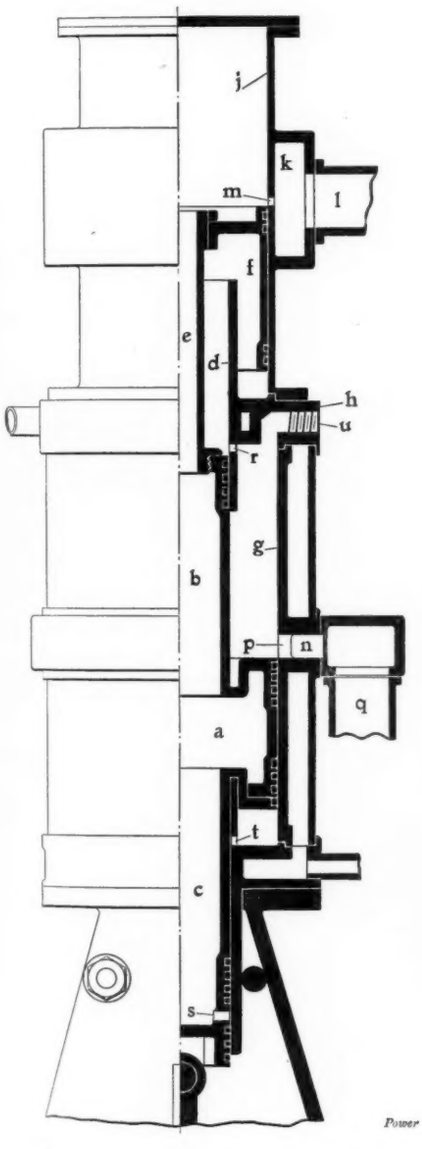


FIG. 1. ENGINE IN PART SECTION

The piston proper *a* is hollow, and from it two hollow extensions *b* and *c* of a less diameter extend upward and downward. The lower end of the lower extension *c* is blanked off, and supports the gudgeon pin for the connecting rod. A sleeve *d*, cast with the upper cylinder head, surrounds the upper piston extension *b*. The upper end of *b* is open, and is threaded to receive a smaller hollow extension *e*, which in turn carries a pump piston *f*. To the cylinder proper *g* are attached the head *h* and the upper pump chamber *j*. Round this pump chamber an annulus *k* is formed, to which a pipe *l* admits the mixture, which enters the pump cylinder through a series of ports *m*. A second annulus *n* is formed midway on the cylinder barrel, this being likewise connected through a series of ports *p* to the interior of the cylinder, whence it takes the spent gases to the exhaust pipe *q*. Ports *r* are also provided in the cylinder head sleeve *d*, at *s* in the lower extension *c* of the piston *a*, and in a second sleeve, which projects upward from the lower cylinder head, one of these ports being shown at *t*.

It will be evident that two annular pressure spaces are formed in the cylinder, one above and one below the piston, and piston rings are suitably disposed to keep these chambers gas tight. Spark plugs are fitted to these spaces, of which that for the upper chamber is screwed into the cylinder at *u*; the corresponding boss for the lower portion is not shown. In the position of the piston here shown, the mixture is free to enter through the induction ports *m* into the pump chamber, and fill the interior of the hollow piston and its upper and lower extensions. The

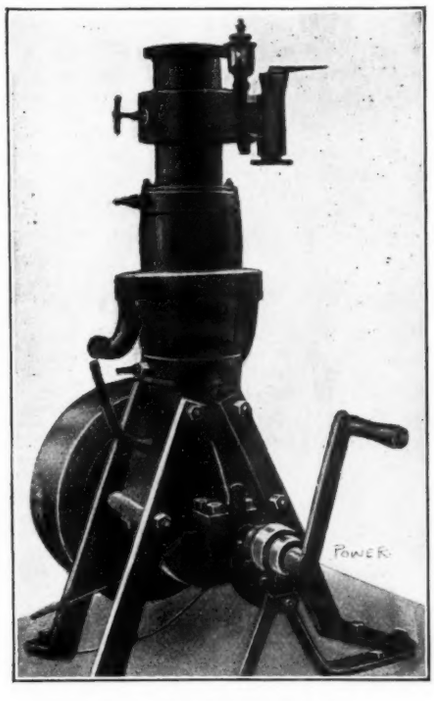


FIG. 2. AN EXTERIOR VIEW

piston then rising by the stored energy from the previous cycle, the port *m* is closed, and the mixture becomes slightly compressed within the pump cylinder and the hollow piston. This compression continues until the ports *s* come opposite the ports *t*, when the mixture flows into the lower explosion chamber, and at the same time drives out the products of combustion from the previous charge through the port *p*, which is now uncovered by the piston proper. As the pump piston is now at the top of its stroke, the ports *m* are once more uncovered, but on this occasion by the lower edge of the piston, so that the mixture flows into the space beneath it.

The piston now descends, cutting off the admission and exhaust ports *t*, *p*, in the lower chamber, and compressing the gas within it. When at the bottom of its stroke it uncovers the admission ports *r* and the exhaust ports *p* for the upper chamber, so that the mixture imprisoned beneath the pump piston can flow into the upper explosion chamber, driving the former products through the exhaust port. Firing now takes place within the lower chamber, driving the piston upward and compressing the charge in the upper chamber, which in turn is fired at the top of the stroke. The cycle is then repeated.

LETTERS

Steadying a Hit-and-Miss Engine

Sometime ago I was called in to look over a little lighting plant in a hotel, which ran unsteadily. A small generator was driven by a gas engine of about double the capacity required and governed on the hit-and-miss plan. The engine ran very irregularly; when an explosion occurred the voltage would rise and then it would gradually drop about five volts before another explosion took place.

I knew where there was a two-horsepower gasolene engine that was out of commission, and that had two flywheels about 18 inches in diameter and 3 inches rim face. I got one of the wheels, had a bushing made for the hub to fit the shaft of the generator and faced off some of the hub; the generator pulley had a 5-inch face, while the belt was only 2½ inches wide, so the pulley was cut off to 2½ inches to make room for the flywheel. The flywheel was put on first, then the pulley, and both keyed in place. This entirely stopped the flickering of the lights, the heavy balance wheel keeping the generator up to its proper speed between the explosions of the engine.

D. M. GROVE.

Covington, Va.

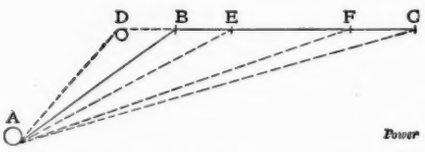
According to London *Engineering*, an 1100-horsepower Cockerill-Westgarth gas engine recently made a nonstop run of more than five months. Two of these engines were installed last year at the works of the Coltness Iron Company, Newmains, N. B. The engines use blast-furnace gas, and develop 1100 brake horsepower each. The leading dimensions are: Gas cylinders, 39½ inches in diameter; air cylinders, 96 inches in diameter; stroke, 43½ inches. The engines are fitted with the Southwark patent sliding air valves, and run at 70 revolutions per minute.

FROM READERS *with* SOMETHING TO SAY

PRACTICAL INFORMATION *from the* MAN *on the* JOB: A LETTER GOOD ENOUGH *to* PRINT *is* GOOD ENOUGH *to* PAY *for*

Faulty Reducing Motion

A few months ago I called at a plant where an expert engineer was taking indicator diagrams to ascertain the power developed per pound of coal during a 10 hours' run. He had the indicator connected as shown in the figure where *A* represents the reducing wheel on the in-



ARRANGEMENT OF REDUCING MOTION

dicator and *BC* the path of the point of connection on the crosshead. The engineer admitted that this did not give him a correct card, but said it was the best he could do as he did not have an opportunity to put a rod on the crosshead before the engine was started in the morning. I suggested that if a guide for the indicator cord was placed as at *D* the error would be eliminated, but he laughed at me and offered to treat if it could be shown that I was right. I accepted his offer and proposed to refer the matter to an engineer in whom we both had confidence. He said that was unnecessary, as we could meet at the office that evening and settle it between ourselves, but when he came to the office that evening he did not seem disposed to take the matter up, so I said nothing further about it.

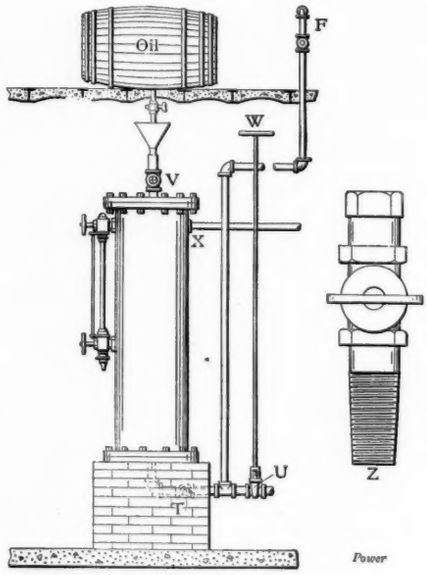
It will not be necessary for an engineer to study the figure very long to see that if the cord were carried around the guide at *D* the movements of the indicator would correspond exactly with the movements of the crosshead. Neither will it take much study to see that if the guide is not used the indicator drum will be moved a shorter distance while the crosshead is going from *B* to *E* than it will be while the crosshead is going an equal distance from *F* to *C* at the other end of the stroke. Now if the points *E* and *F* are one-fourth of the length of the stroke from the ends it will readily be seen that while the piston is moving through the first quarter of the out stroke the indicator drum will be turned less than one-quarter of the full travel and while the piston is moving through the first quarter of its in stroke the indicator drum will be moved more than one-quarter; therefore the diagram for the head end will have less than its true area and the diagram for the crank end will have more than its true area. The sum of the areas cannot be depended upon to equal the sum of the true areas because the rate of variation at the head end is greater than at the crank end, and hence the distortion of the part of the diagram at the head end containing the greater area is more than that of the crank end.

G. E. MILES.

Denver, Colo.

Oil Storage Tank

A homemade oil-storage tank is shown in the figure. In the station yard we found a piece of 16-inch cast-iron pipe, 7 feet long and flanged at both ends. A brick foundation was built for it in the basement, and the pipe was set as shown. A gage glass, which could be seen from the engine-room floor by raising a trap door, was installed on the side of the pipe. A hole was drilled and tapped in



ARRANGEMENT OF STORAGE TANK

the upper head and a 3-inch pipe was inserted having a valve at *V*. A funnel was permanently fastened in the 3-inch pipe so that the top came just below the engine-room floor. The lower end of the 16-inch pipe was drilled and tapped for a ¾-inch pipe with a valve at *T* and a blow-down valve at *U*. This valve was operated from the engine-room floor by the long stem and wheel *W*. Water was taken from the city's main and passed through the ¾-inch pipe above the engine-room floor, through valve *F* and into the base of the 16-inch pipe. A 1-inch pipe was taken off at *X*, and from it connections were run to the six lubricators we have in service. The tapered straight-way cock shown at *Z* was made to be inserted in the bung-hole of the oil barrel when filling the tank.

To fill the lubricators, valve *T* was opened allowing water pressure to enter the 16-inch pipe and force up the oil through the supply line at *X*.

W. A. DOW.

Cambridge, Mass.

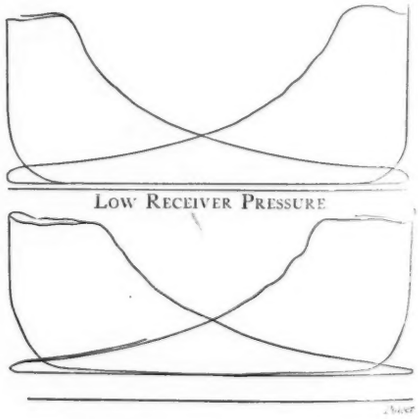
Receiver Pressure

The effect of high and low receiver pressure on the point of cutoff in the high-pressure cylinder of a compound engine having a fixed load, is generally accepted to be a shortening of the point of cutoff with a lowering of the receiver pressure.

The accompanying diagrams, although not ideal, show this at a glance.

They were taken from a 10 and 22 by 30-inch tandem-compound engine, direct-connected to a direct-current generator, running at 125 revolutions per minute.

The load remained constant and the



LOW RECEIVER PRESSURE

HIGH RECEIVER PRESSURE

low-pressure cutoff was adjusted with a hand screw at the governor stand.

In the same plant are two cross-compound engines, 22 and 48 by 42 inches, driving 750-kilowatt, three-phase generators, connected in parallel.

If, when the load is equally divided between the two machines, the receiver

pressure is raised on one and lowered on the other, the load of the former will decrease and that of the latter increase.

These machines are not provided with indicating wattmeters, so the actual difference in output cannot be readily determined.

LOUIS F. COOLING.

Dixon, Ill.

Experiences with Damper Regulators

I was once called in by a neighboring engineer to determine the cause of his damper regulator's failure to operate properly. It took but little time to determine that the trouble was due to a sediment-clogged water pipe. After thoroughly cleaning and reconnecting the pipes, the apparatus performed its function as well as ever. On departing, I casually remarked that a little soap placed in the settling chamber *A*, Fig. 1, would help to lubricate the plunger rods. The next day I was surprised to be called upon again to doctor the regulator for the same trouble, namely, a clogged water pipe. After some judicious breaking of joints, it occurred to me to ask the engineer what kind of soap he placed in the settling chamber.

"The best I had," he answered, "Ivory soap."

"Ivory soap," I replied, "may be good in a bath tub, but it is mighty poor stuff to put into the settling chamber of a damper regulator. It floats."

At a certain small mill the regulator was set up in a very convenient but rather exposed position, with the consequence that on cold nights the cooling water in the lower diaphragm chamber was often found frozen. To prevent this the drip pipe *B*, Fig. 1, was introduced to drain it, and the ⅜-inch pipe *C* was connected up with the water pipe to refill the chamber with water upon starting up in the morning.

In plants where the water used to operate this style of damper is under a pressure of 50 pounds or more, it is often found difficult to keep tight the two plunger-rod stuffing boxes without excessive pressure on the packing. A neat way to take care of this leakage, if one is particular about the appearance of the floor, is shown at *D*, which is a flared-end, cold-rolled copper funnel, piped to the waste-water pipe from the plunger chamber.

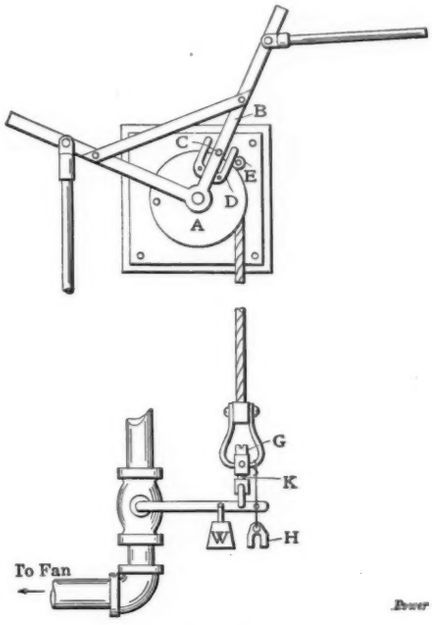


FIG. 2

At a certain plant a new regulator was installed to operate the damper and control the induced-draft fan of the boilers. For some time the regulator failed to work satisfactorily, and it was inferred that it was of too small a size. One day the fireman disconnected the chain leading to the fan valve, and in replacing it accidentally made it slightly longer, with the result that the regulator worked like a charm. The whole trouble was caused by attempting to close the damper ahead of the fan. The arrangement finally adopted to operate the damper and fan is shown in Fig. 2. The sheave *A* is free to move independently on the shaft of the bell-crank lever *B*. The pin *C* extends between the prongs of the fork end *D*, which is riveted to the sheave. The right-hand tine is shown resting against the stop *E*. The arrangement is shown as it appears when the damper is closed. It will be noticed that the damper will open considerably before pin *C* travels the clearance and engages with the left-hand tine, and cause the fan to start. In the same manner, the weight *W* will shut off the fan before the damper is closed. It was found that the speed of the fan, when subject to the will of the fireman, was being abused. To limit the speed, and still permit of slight changes, the chain was shortened to within a foot of the sheave, and a light iron rod substituted. The connection between rod and lever was made as shown. By screwing down the bolt *G* more steam is admitted to the fan engine. The speed at which damper and fan worked to best advantage was obtained by inserting the slotted washer *H* in the space *K*, and securing it there by the bolt. To find this washer out too often was deemed sufficient cause for a reprimand.

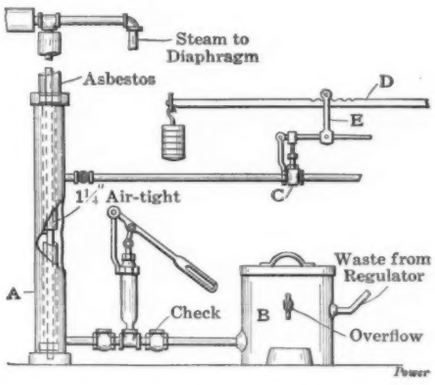


FIG. 3

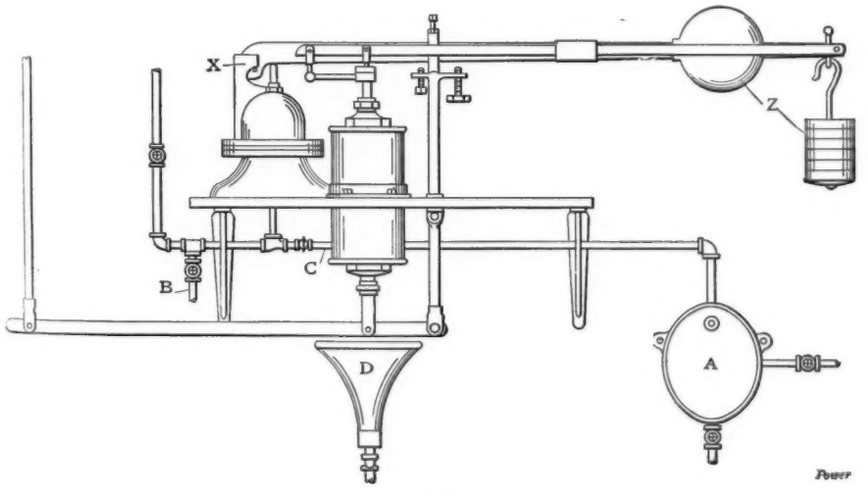


FIG. 1

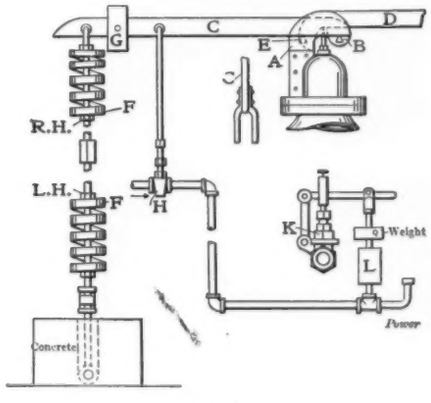


FIG. 4

At a mill built in the suburbs of a small town, water under sufficient head could not be obtained to operate a regulator satisfactorily. To remedy matters, the engineer connected the water plun-

gers, as shown in Fig. 3, to the same steam pipe that furnished pressure to the diaphragm. A 6-foot piece of 6-inch pipe *A* was placed in series between the two connections, and the pipes then filled with water before turning on the steam. The waste water from the regulator is collected in the tank *B* and once in a while pumped back into the system with the force pump shown. Thus but very little steam was condensed in the system. It was found, however, that the pressure was excessive. To reduce it, the small sliding-stem valve *C* was piped in line with the regulator weight lever *D*. The two levers were connected by the link *E*. When the damper is open valve *C* is closed, and opens only on the rising of lever *D*. The amount of opening is regulated by the position of link *E*, which is free to slide on both levers. The farther away it is placed from the valve, the less will the valve open, and the more will the pressure be reduced.

A unique use for a damper regulator is to be found in a large hotel where, owing to faults of building construction, it almost amounts to a crime to permit the safety valves to blow. As the worried engineer could not always depend on his firemen, he tried several schemes to muffle the valves, the most efficacious of which, however, was ordered to be removed by the boiler inspector. While doctoring the damper regulator one day, the idea came to him to use this reliable machine to blow out the surplus steam in the boilers. His scheme is shown in Fig. 4. The top portion of the sustaining post *X*, Fig. 1, was sawed off and the plates *A*, Fig. 4, two in number, were riveted on to carry an additional sustaining point at *B* on the right-hand side of the diaphragm rod. Then the lever *C* was formed and placed in such position as to bear on the knife edge of the regular weight lever *D*, as shown at *E*. The two springs *F* were given sufficient tension to balance the weights Z, Fig. 1. Now, by placing the weight *G*, Fig. 4, on lever *C*, it will be apparent that the damper is restored to its original condition, with this difference, however, that after raising the regular lever *D*, the steam pressure will also lift the lever *C*. The amount of lift is, of course, limited, and weight *G* should be heavy enough to permit of, at least, a two-pound difference in pressure between the lifting points of the two levers, and the pressure should be within two or three pounds of the pressure for which the safety valves are set. Attached to lever *C* is the elongated stem of the small, quick-opening valve *H*, placed in a continuation of the regulator water pipe.

The three boilers of this plant are equipped with patented steam soot blowers, controlled by the sliding-stem gate valve *K*. By connecting the opening lever of this valve to the piston of the small hydraulic cylinder *L*, piped to the same water line, it will be obvious that when valve *H* opens, admitting water under pressure to cylinder *L*, valve *K* will also open, and some useful work is done with the surplus steam that would otherwise be blown out through the safety valves, causing annoyance to the hotel guests, and cutting the seats of the safeties. Of course, it must not be inferred that the safety valves are never allowed to blow. A special time was appointed when this was permitted each day.

K. P. Everette.

Boston, Mass.

Contract Guarantees

A firm representing certain engine builders contracted to erect an engine for us at a sawmill. They represented the engine as being capable of developing 300 horsepower under a steam pressure of 110 pounds and at a speed of 175 revolutions per minute. At my suggestion this was incorporated in the guarantee. These people reasoned that it would be safe to give the guarantee as in most instances where the load is as variable as it is in a sawmill, it is impossible to determine the performance of the engine.

The sawmill was put into operation after the engine had been installed and the engine people came around and wanted to collect their pay. They said, "See, the engine runs the mill, it is making good, pay up."

The owners put the matter up to me; they asked, "Will it comply with the guarantee? If you say it will, payment is ready."

I erected a brumbo and connected an indicator of standard make to each end of the cylinder; both indicators were attached to the brumbo. To the main shaft I belted a tachometer which I knew was accurately calibrated. Simultaneous diagrams were then taken and the speed of the engine was noted at the instant the diagrams were being drawn.

The engine was of the slide-valve, ball-governor type. The speed was found to vary from 140 to 200 revolutions per minute. The power developed was found to range between 260 to 325 horsepower. By repeated trials I found that at a speed of 175 revolutions per minute the engine did not develop more than 280 horsepower.

The matter was adjusted without a law suit but substantially according to the terms dictated by the purchasers.

I could not understand why the manufacturers would be insane enough to make a guarantee so strong that the engine could not comply with it and consequently I wrote to them about the matter. They promptly replied and denied having given their authority to the agents to make any such guarantee and as evidence they sent a copy of their catalog which rated the engine 15 per cent. lower and gave as its normal speed only 145 to 150 revolutions per minute.

The moral is that those who guarantee a machine to do more than it is designed to do, are sure to get into difficulty sooner or later.

E. T. Abbott.

Pokegama, Ore.

An Ingenious Makeshift

During a night run at a refining plant the stuffing box of a centrifugal pump, circulating hot acid, started to leak badly and as nobody noticed it the belt got soaked and came off the flywheel of the driving engine, a small vertical slide-valve machine, which started to race. The governor belt came off and there was more racing. The foreman tried to stop it, but the wheel of the ¾-inch globe valve, which controlled the engine, had come off as a result of the vibration. While he was getting a monkey wrench the crank shaft broke off flush with the outside end of the main bearing. The flywheel "eloped" with the piece of the broken shaft and brought up against an acid tank, after which it did no further damage. At last the engine was stopped. The night engineer told the foreman that they would have to get a new crank shaft from the builders of the engine before it could again be operated.

The assistant engineer, coming in at 7 a.m., learned of the accident and went at once to see what could be done until the new crank shaft could be obtained. The engine had two flywheels, and after he had taken a few dimensions he found that if the engine were turned just half around he could drive the pump with the other flywheel. At once he obtained the proper assistance, one man repacked the leaky stuffing box on the pump, another man fixed the belts, the pipe fitter cut two nipples, and the assistant engineer with two helpers disconnected all the piping and took off the nuts of the foundation bolts. The engine was lifted high enough to clear the foundation bolts and turned. After the engine was leveled, the flywheel was found to be in line with the pulley of the pump. The crank was placed on dead center and the position of the valve stem marked, then the set screws of the eccentric were loosened and the eccentric moved around until the mark was in the same position again. Then the pipes were connected, and at 8 o'clock the engine was running again as smoothly as ever.

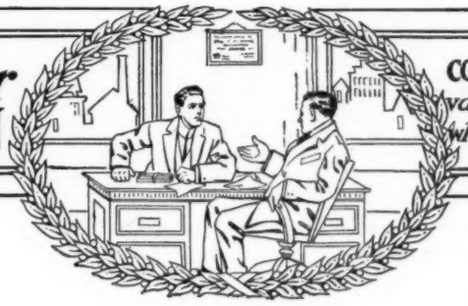
The new crank shaft arrived and was fitted on a week later.

W. G. Werbeck.

Saratoga Springs, N. Y.

Unto those who talk and walk
This proverb should appeal;
The steam that blows the whistle
Will never turn the wheel.—*Ex.*

SUBJECTS *under* DISCUSSION



COMMENT, CRITICISM, *and* DEBATE *upon various* ARTICLES, LETTERS *and* EDITORIALS *which have* APPEARED *in* PREVIOUS ISSUES

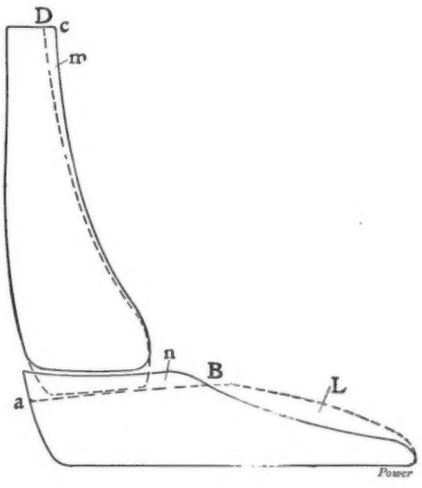
Receiver Pressure in Compound Engines

In the January 18 issue W. E. Crane asks, "If expanding in a steam pipe superheats the steam why is it not just as reasonable to conclude that expanding in a cylinder superheats it; neglecting the small amount of heat consumed in performing work * * *?"

It would be if the amount of heat taken out as work were small enough to be negligible, but this is not the case. The steam tables which I have give the total heat of steam at 140 pounds, absolute, as 1189.56 B.t.u., and at 30 pounds, absolute, as 1158.28, a difference of 31.28 B.t.u. If a compound engine uses 15 pounds of steam per horsepower-hour, it uses one-quarter pound of steam per horsepower-minute. One horsepower for one minute equals 33,000 foot-pounds of work and is equal to 42.5 B.t.u., very nearly. This 42.5 B.t.u. must come out of that one-quarter pound of steam and if the high-pressure cylinder does one-half the work, 21.25 B.t.u. are taken out in the high-pressure cylinder. If 21.25 B.t.u. are taken from one-quarter pound, or 85 B.t.u from one pound and the pressure drops from 140 pounds to 30 pounds where the difference of the total heat is only 31.275 B.t.u., some of the steam must condense. The steam per horsepower-hour could be more than doubled without getting dry steam in the receiver. The steam which escapes at release, when the pressure in the cylinder drops to receiver pressure, is forced out by the expansion of the steam left in the cylinder at the point marked *X* in the accompanying figure. This work will cool this steam just the same as though it were following a piston. The steam which loses pressure by going through the exhaust valve, though, will be partly or wholly dried or even superheated, according to how wet it was and how much pressure drop there is. From this it will be seen that even in an engine taking steam full stroke, the cylinder walls are exposed to the temperature of steam at receiver pressure.

If steam expands it loses temperature, but if that expansion is used to impart velocity to the steam and the velocity is changed back to heat, by eddy currents, etc., the steam will be superheated. Thus in a De Laval turbine nozzle, the steam expands, gets wet and receives a high velocity. If the nozzle were in a pipe so that the velocity was lost in eddy cursents and friction, the steam would become superheated; but if the velocity were taken out by a turbine wheel, the steam would remain wet.

It is true that the exhaust valve is open only a small fraction of a second, but it opens a good many times during a day's run and the cylinder walls are exposed to the low temperature nearly one-half the time. As the walls are hotter than the steam at the low pressure, any water on them will be partly evaporated. If only one B.t.u. per stroke were used it would amount to 150 B.t.u. per minute in an engine running 75 revolutions per minute, or more than enough heat to develop three horsepower.



COMBINED DIAGRAMS

In the accompanying diagram if the receiver pressure is lowered as shown by dotted line *a B* and the cutoff changes from *c* to *D* in the high-pressure cylinder in order to get the same area of diagram, the toe of the low-pressure diagram must be enough higher to make up for areas *m* and *n;* thus area *L* equals area *m* plus area *n*. The volume and pressure of steam near release in the low-pressure cylinder is as true a measure of the steam used as the length of the cutoff in the high-pressure. I do not mean by this that a high governor always means more steam, but that a high governor does not always mean less. It is very probable that a simple engine with a cylinder the size of the low-pressure cylinder would cut off fewer cubic inches of steam than the compound, but the toe of the diagram would be higher and more steam would be used for the same work. The steam for area *L* was water in the high-pressure cylinder and was evaporated by heat from the cylinder wall.

If Mr. Crane found that the engine which he tested really used the least steam with two pounds receiver pressure, that is certainly the receiver pressure for him to carry; but if he only found a shorter cutoff he may be mistaken.

In any case where the steam used can be actually measured the receiver pressure which gives best economy can be found by testing; otherwise the builder's advice should be followed even though some other pressure gives a higher governor plane.

HARRY D. EVERETT.

Jamestown, N. Y.

Low Receiver Pressure

In the January 18 number, William Westerfield makes some statements regarding receiver pressure, and shows some diagrams taken from a low-pressure cylinder.

Mr. Westerfield states that, one morning about eight o'clock, he was called to the plant, and upon arrival there, found the low-pressure cylinder taking steam almost full stroke. The receiver gage showed 30 pounds pressure. Further, Mr. Westerfield explains (?) how the engineer had got almost boiler pressure in the receiver, so that the spring of the receiver gage was distorted sufficiently to cause the gage to indicate 20 pounds pressure, when actually there was no pressure in the receiver, and the gage, therefore, should have indicated 0.

From this, which is given in Mr. Westerfield's letter, it is clear that the actual receiver pressure at the time he arrived at the plant was 10 pounds.

Mr. Westerfield states that, when he looked around, he thought he knew where the trouble lay, but determined not to lose the opportunity to get a freak diagram. He states that the diagram in Fig. 1 is what he got. The diagram shows, as Mr. Westerfield has stated, that the point of cutoff was very late; it also shows that instead of 10 pounds pressure the receiver contained, apparently, 5 to 10 inches of vacuum. It appears strange to me that the diagram contradicts the conditions as described by Mr. Westerfield.

HARRY W. BENTON.

Cleveland, O.

Mechanical Boiler Cleaners

In the January 25 issue of POWER is an article by W. A. Garrigus on mechanical boiler cleaners. I am glad to see someone, in these days of compounds, chemical treatments and kerosene oil, who has the courage of his convictions and stands by a good thing.

Some years ago, while in a plant using Southern river water, a representative of a mechanical-cleaner concern induced the owner to allow him to install one of his cleaners. At the time, I could not see where it would fit and did not believe it would do any good.

When it was put in there was about ¼ inch of scale on the lower sheets, with considerable on the tubes. We opened the boiler about two weeks after the cleaner had been put in. I did not count them but it seemed as though there were at least a million pieces of scale lying loose over the fire. Every second Sunday it was the same for two or three months, when nearly all the scale had loosened from the shell and the tubes were so clean that I don't believe a knocker would have thrown down a handful. When the river was high and there was plenty of mud in the water we blew out the settling tank every three hours and generally got an inch stream of mud for about a minute before any water showed itself. When there was little or no mud we blew every four hours and always got a lot of soft sludge but no hard scale ever stuck to either shell or tubes. There was always a small amount of thin scale lying loose over the fire which could be easily taken out through the front manhole.

The mechanical cleaner is the simplest proposition that can be imagined and any intelligent engineer can easily design one to fit his conditions. There can be no valid patent on the simple cleaning apparatus as it has been on the market at least 25 or 30 years.

There is another use for such an apparatus which occurs to me as a very likely one. Why not turn the settling tank upside down, putting the blowoff at the top, and use it to remove oil that may be fed to the boiler with the feed water? Has anyone ever tried this? If so, let us know what the result was. Then again, could not the pipe from the skimmer enter the settling tank at the center of one end and the return for clean water be taken from the center of the opposite end? Could not the oil blowoff be taken from the top and from the bottom the mud blowoff? If this arrangement is practical, we have a combination mud, scale and oil separator.

If the time ever comes when I will have an opportunity to try experiments, I shall certainly try this scheme, unless some reply stating that they have tried it and proved it to be useless. I am not advertising anybody's apparatus nor knocking any, but there is certainly a good field here for experiment and there is absolutely no cost of operation or maintenance after the installation has once been made, with the exception of a new valve occasionally on the blowoff. Will not some engineer who has had experience with mechanical cleaners give the benefit of his practice to the readers of POWER?

G. F. BARKER.

Dorchester Center, Mass.

An Early Marine Engine

The February 8 number of POWER contains a short note in regard to an early marine engine.

Something was said about the inventor having experienced some little trouble with tar in the cylinders as you would expect, though this was overcome as claimed by Bennet.

I cannot see anything in this except levity at his expense, since the fire was fed through the stack and not a particle of the effects of combustion, etc., was lost, but all were, instead, forced into the boiler, etc.

It seems that U. R. A. Nother, in a recent issue, proved to POWER readers that he was a good surgeon where he told of a boiler being affected with a "tar blood blister." Can it be that he profited by Mr. Bennet's experience?

LOYD V. BEETS.

Nashville, Tenn.

Paterson Economizer Explosion

In the February 1 number of POWER I noticed a description of a disastrous explosion of an economizer. Two theories are advanced as to the cause. I have had considerable experience in the operation of economizers and do not hesitate to say that, in my opinion, gas was not the cause of the explosion. The walls of an economizer are only 8 inches, or, at the most, 12 inches thick, and would undoubtedly have given way and released the gases without causing such excessive damage.

The economizer was supposed to have been repaired and cut into service again. This was proved to be not so and the economizer was still out of service. What would be more natural than for someone, a fireman, say, to open the dampers to the economizer chamber and then to go to the feed-water outlet to the boilers and open this, thinking all the time that the economizer was full of water and had been tested by the repair man for leaks? It is evident that the boiler check valves would not let any water flow back from the boilers. No doubt, when the man found he was not getting enough water to supply the boilers he would naturally investigate and, finding the inlet valve closed, open it, still under the impression that the economizer was full. The result would be exactly similar to what happened, practically a boiler explosion. The safety valve could not take care of such a large quantity of steam that would be generated by the water rushing in onto the hot castings.

It would be interesting to know if this economizer had baffle plates cast in the manifolds to force the circulation of water. If it had, I do not think the explosion would have been general, but would have been confined to one end. If there were no circulation plates, then the water could rush straight across the manifold and wreck every section, as in this case.

While Chief Engineer Merrill's theory is good, I am sure that if the economizer was full of water and the steam generated gradually, it would have found a weak spot or casting, and when exploding would not have proved so disastrous.

GEORGE H. HANDLEY.

Newburgh, N. Y.

Beare of Corrupt Salesmen

There has been a good deal of discussion about the way in which salesmen treat engineers and their assistants. I wish to tell of the type which I consider the worst of all.

He is the man who goes first to a neighbor engineer and finds out your name, then comes into your engine room with outstretched hand and says, "How do you do, Mr. So-and-so," in a way that makes you think he is some friend that you have forgotten. He talks about the weather awhile and finally says that he represents the Punk Oil, Waste and Packing Company, and wants to know where you buy your stock and what you pay for it. He usually tells you that he can sell you material which is just as good at a cheaper price. If you tell him that you are satisfied with the house you are dealing with at present he gets real confidential and says, "I tell you what I will do with you; if you will give me your trade I will give you 10 per cent. on every order you send in."

Now an engineer with a sensitive disposition will drive him out of the plant at once, others will think it over a few minutes and then say no, but there are a few who will accept his offer; these don't stay long on any job.

This salesman never bothers the old engineer, the man who has been in the business a long time. It is the young man just in the first position where he is allowed to buy his own stock, that this gentleman is after.

Money we all like; we cannot any of us get too much of it; but if you accept it from this salesman, you are selling your reputation as an engineer and an honest man.

All salesmen are not like this one; some companies will not allow this kind of business, but there are a few that will

and there are cases where the salesman does it on his own account and charges it up to sundries or miscellaneous on his expense account.

L. W. CHADWICK.

Bridgewater, Minn.

Pound in an Engine

I little thought when writing my letter about the pound in our engine, that it would stir up all the comment which it has.

In the January 18 issue, Mr. Row suggests that I tell just where the pound was finally located. I am compelled to confess that, as yet, it has not been located. The plant is not run with economy in view. As long as the wheels are kept turning, "let her pound."

In justice to myself, I wish it to be known that I never had any say in the management of the engine.

Some of the readers have suggested that the pound was caused by the governor. This is not the case, however, as the governor is of the throttling and not of the automatic type.

LE ROY SCOTT.

East Jordan, Mich.

Repair of Broken Piston Rod

Mr. Billan's article in the January 11 number, brings to mind two experiences I had with two Armington & Sims engines equipped with the taper-and-wedge style of piston rod.

The engines worked on a street-railway load with a swing from practically no load to 50 per cent. overload, so that they had considerable to contend with. They ran at 175 revolutions per minute and were rated at 200 horsepower each.

One night, when the load was very heavy, the piston rod on No. 1 engine broke at the slot in the taper and where it was keyed into the crosshead.

The piston and rod came through the back end of the cylinder, breaking the head into several pieces and pulling out several studs and breaking the rest. Where the studs pulled out, the cylinder was cracked so that it required a large patch.

We had a new crosshead and rod made of the thread and lock-nut construction and put in place, tapped new holes for studs each side of the cracks in the cylinder and put on a new head. The engine ran satisfactorily until it was removed to make way for a larger unit about a year afterward.

Engine No. 2 caught a slug of water one night; but instead of the rod breaking, the taper end was driven far enough into the crosshead neck to crack it open but not enough to let the key out of the crosshead pin still holding the sides together.

The engine was stopped before any further damage was done and a new rod and crosshead of the thread and lock-nut style were procured and put in place; this engine also ran without further trouble until replaced by a larger unit.

In driving the wedges in a taper rod if you do not drive them in tight, they are very apt to work loose, and if you drive them too tight something is likely to let go. I do not consider the taper-and-wedge style of piston rod to be good construction.

J. G. DENNINGTON.

Oil City, Penn.

Boiler Safety Appliances

I read in the January 11 issue an article on boiler safety appliances. It stated that it is bad practice to have water glass and gage cocks connected only to the water column and that there should be a glass and gage cocks connected directly to the shell of the boiler. It is stated also that the general rules and regulations of the Government Board of Supervising Inspectors call for this.

I would now like to know how a glass and gage cocks could be connected directly to the shell of a horizontal return-tubular boiler so that they could be seen at all times. The boiler is surrounded with brick and has a cast-iron front which is from 18 to 20 inches away from the front head of the boiler. On marine boilers it is not a very difficult thing to accomplish, but I would like to know how it can be successfully done in the case of most stationary boilers.

The article states that there should be no valves placed between the boiler and water column. I believe this to be good practice because some careless person might close these valves for some reason and afterward forget to open them, and an accident would be the result. On the other hand, if valves are not placed in the connections between the boiler and water column, there is no way in which to shut the steam and water off, if something should happen to the water glass while the boiler is under steam.

In our plant there are no valves between the boiler and water column; but if there were, it would be a mighty handy thing just now, for there is something wrong with the water column and the only thing to do is to blow off the boiler and disconnect the glass in order to see what is the matter.

There is one more reason why I think there should be valves between the water column and boiler. When one blows out the column it is hard, sometimes, to determine whether there is steam or water or both coming out and one of the pipes might be clogged up and you would not know which one it was. If there were valves in the steam and water pipes it would be a very easy matter to find out which was fouled, simply by closing one of the valves.

W. A. DOEHLER.

Two Rivers, Wis.

Kerosene in Boilers

In the January 11 issue of POWER Mr. Horsfall gives us a new theory as to how kerosene oil loosens scale in a boiler.

His theory is that if the oil is put into an empty boiler and then the water slowly added, the oil, being lighter than the water, will reach the scale first and be absorbed by it. On getting up steam the oil will be vaporized and in expanding will disintegrate the scale just as carbon dioxide formed from yeast loosens and breaks up bread dough. Did it ever occur to Mr. Horsfall that in a boiler to which kerosene has not been added the scale will absorb water instead of oil and the water will be vaporized in the same way as the oil? Then why go to the trouble of adding the oil? But did anyone ever hear of steam having any such effect on scale?

Another flaw in Mr. Horsfall's reasoning is that he has used the flash-point temperature of kerosene, 150 degrees Fahrenheit, as the vaporization temperature, which is some 130 degrees higher than that of water, so that the oil would not be turned into gas while getting up steam, which is necessary in order to have the theory hold good.

Washington, D. C. JOHN FRENCH.

Babbitting a Main Bearing

I read with interest F. L. Johnson's article on how to babbitt a main bearing. However, I fail to understand what he means when he says: "In the ordinary four-part bearing, consisting of bottom, top and two side shells, only the bottom and side pieces should be babbitted. As the top does not, should not and cannot touch the shaft while the engine is in operation, all time, effort and metal used on it are time, effort and metal wasted." I cannot believe that this has ever been practised. I would like to hear what other readers of POWER think about it.

I do agree with him and others that scraping a bearing is tiresome and expensive work and that often better results are obtained with Sapolio and water. I have also used for this purpose powdered soapstone where white brass or bronze is used in horizontally parted bearings. This latter method is quite frequently used by gasolene-motor builders. The soapstone is mixed with the oil while the engine is being "limbered up."

GEORGE C. BELLING.

Hammondsport, N. Y.

Cylinder Lubrication on the Great Lakes

In regard to the use of oil in the cylinders of marine engines I will contribute my experience to the store of knowledge on the matter.

On the boat on which I work there are two triple-expansion engines and each is equipped with force-feed oil pumps. The quantity of oil pumped into each engine is about one quart in 11 or 12 hours. The exhaust steam is received by jet condensers and from these the boilers are fed.

The boiler equipment consists of four modified locomotive-type marine boilers. The boilers were in continuous operation for four months. When they were opened at the end of the season, no evidence of a particle of oil was found in them.

We have two engine-driven fans for ventilating the fire hold and engine room. On each fan engine there is a half-pint lubricator. These lubricators are filled once a day. These engines run slowly, consequently the lubricators are choked off considerably.

On the electric-light engine there is a one-pint lubricator which is filled every three hours on account of the engine running at a high speed.

We use 600-W cylinder oil in all our engines.

D. C. CHITTENDEN.

Brantford, Ont.

Cylinder Condensation

In a recent issue there is a letter from W. E. Crane, on "Receiver Pressure in Compound Engines," in which he mentions that, "When steam is expanded in a cylinder it does not condense; it follows the same law as though expanded in a steam pipe."

Dry, saturated steam expanding in a cylinder does work because motion of a piston is the result, while steam expanding in a steam pipe (free expansion) does no work, as motion does not take place. The total amount of heat in the steam is the same but there is a reduction in pressure which causes the steam to become superheated. In the steam engine, the total amount of heat has been diminished by expansion as most of it has been transformed into work. There is superheated steam in a cylinder when the exhaust is open and the steam is expanding into a receiver or the atmosphere. This superheating of the steam is caused by a reduction in pressure and the heat given up by the cylinder walls which were at a higher temperature a moment before the exhaust opened. The condensed steam in the cylinder due to expansion and loss of heat on the forward stroke is then evaporated on the return stroke. Then when steam is admitted, the walls of the cylinder have a lower temperature than the incoming steam and part of the heat contained in this steam goes to raising the temperature of the walls again. This heating of the walls of the cylinder means a loss of heat and initial condensation. In compound engines initial condensation is reduced by dividing it between two cylinders. All the steam condensed in the first cylinder is reëvaporated and is capable of performing work in the next cylinder. The condensation in the second cylinder is due to its own range of temperature, which is far less than it would be in a simple engine having the same range of expansion as the compound engine. This is why the compound engine is economical.

THOMAS BROCKMAN.

New Orleans, La.

Compression

In POWER of January 25, I read a communication from C. E. Bascom on the reason why compression saves water in a steam engine. One of the arguments which he advances I want to correct as it is erroneous, and one which is often used against reciprocating engines.

Mr. Bascom says that the power necessary to bring the reciprocating parts to rest at the end of the stroke must be taken from the momentum of the flywheel and therefore if the work given out by the reciprocating parts is used up in compressing steam it is a saving in power. But if the reciprocating parts are capable of giving up kinetic energy in compressing steam, why must they absorb energy from the flywheel if there is no steam to do work upon? If there is no steam to compress, the kinetic energy in the reciprocating parts due to their mass and velocity will be transferred to the flywheel and actually add to its energy. This can be seen if we make a sketch of the moving parts of a simple engine when they are near the end of the stroke, and indicate the motion of the different parts by arrows. When the reciprocating parts are once set going they will tend to keep on going and will exert a force in the direction of their motion. This force is in the same direction as the steam pressure and acts in the same direction at the crank pin as the force due to the steam. Thus this force is added to that of the steam and actually helps. The power necessary to slow down the reciprocating parts must come from the external work the engine is doing through the medium of the transmission, unless there is compression, and then the work is done in compressing the steam and that much power is removed from the energy in the flywheel. It will be asked, how do the reciprocating parts get the energy? It is absorbed from the available work in the steam, or from the energy of the flywheel if you consider all the energy shown by the indicator diagram as going into the flywheel. That is, during the accelerating part of the stroke the parts absorb work and during the retarding part of the stroke they give it out. This interchange of energy does not affect the power of the engine but simply changes the distribution along each cycle, for it can easily be shown that the work absorbed is equal to that given out and so none is lost.

F. S. DELLENBAUGH, JR.

New York City.

Federal Boiler Inspection Laws

There have been published recently many articles dealing with boiler explosions, boiler inspection and boiler construction. Upon investigation I find that the majority of explosions are apparently due to defects in construction. A great many occur shortly after starting up, or just after hooking the boiler into service. I think it is high time that there were enacted laws governing the construction of boilers for stationary practice that would be as rigid as those of the marine service. Many boilers manufactured for stationary service will stand a hydrostatic pressure of one and a half times the steam pressure allowed, but when put into service these boilers fail due to defects in design causing unequal expansion and contraction.

Several days ago I saw a boiler that was built by one of the leading manufacturers. It was a 72-inch shell composed of ½-inch sheets. There were no stamps to be found on any of the sheets showing their tensile strength. The manufacturers guarantee the boiler for 100 pounds pressure, although it has never carried more than 60 pounds, and about three-fourths of the time it has been used simply as a heating boiler and carried a pressure of only two pounds. The sheets over the fire were badly blistered. When the water was drawn off the interior was found to be absolutely free from scale and there was no trace of oil. In my opinion, this indicates that the damage was due to an unequal expansion and contraction of the sheets.

If laws were enacted similar to those in force in the marine service, a sheet would have to be inspected when it was rolled and stamped by an inspector. The boilermaker would have to give an affidavit to the effect that the material had been properly installed. And finally the installation would have to be inspected by a local inspector and his certificate obtained before the boiler could be put into operation. We should then begin to eliminate some of the causes of boiler explosions.

Local inspection laws made by city or county councils are feeble attempts to obtain first-class inspection service. There are boiler inspectors in some cities who have never operated or inspected a boiler before they were appointed. The time is fast approaching when the boiler manufacturers will be compelled to build

boilers of such construction that they can be forced to their maximum rating. I believe that the time has passed when two boilers will be used where one can be made to do the work. Just this point alone is one reason for the necessity of boilers being better made.

S. J. FOLER.

St. Louis, Mo.

Fuel Oil

In POWER, January 18, P. J. Brant makes inquiries concerning the use of oil as fuel.

In POWER, June 16 and June 23, 1908, Prof. William D. Ennis' articles on "Burning Oil for Power and Heating" are valuable to every engineer interested in oil as fuel.

In the figure are shown diagrams of eight types of furnace construction as presented on the Naval "Liquid-Fuel" Report.

While these furnaces are for water-tube boilers, the principles they embody can easily be adapted to almost any style of boilers.

Professor Ennis' tests gave flue-gas temperatures ranging from 447 to 626 degrees Fahrenheit at rated capacity of boilers with rates of evaporation ranging from 3.3 to 4.4 pounds of steam per square foot of heating surface per hour and an equivalent evaporation per pound of oil of between 13.5 to 16 pounds of steam.

In POWER of October 19, 1909, is a statments of results obtained during a 16-months' run at perhaps the best fuel-oil plant in the world—the Pacific Light and Power Company's station at Redondo, Cal. A short description of this plant appeared in POWER, September 15, 1908. A detailed description of their system of automatic regulation of oil firing is there promised, the appearance of which we are still awaiting.

In Table 1 are some data of two tests of a 500-horsepower Stirling boiler at the plant of the Los Angeles Gas and Electric Company, Los Angeles, Cal.:

TABLE 1.

	Test No. 1.	Test No. 2.
Oil-gage pressure	25	32
Temperature of oil, degrees Fahrenheit	198	193
Temperature of flue gas	518	548
Per cent. of water in oil	9.87	9.16
B.t.u. per pound of oil as fired	17,122	17,241
B.t.u. per pound of oil, water free	18,997	18,979
Pounds of water evaporated from and at 212 degrees per pound of oil as fired	14.32	14.84

In Table 2, data on specific gravity, B.t.u. and sulphur of some western oils are given as published in a leaflet by the California Association, N.A.S.E., No. 2 of Los Angeles.

If a fellow does not possess the information he wants the next best thing is to know where to get it. In McGraw-Hill Company's book catalog, several books are listed which deal with liquid fuel.

FRED W. AXE

Del Mar, Cal.

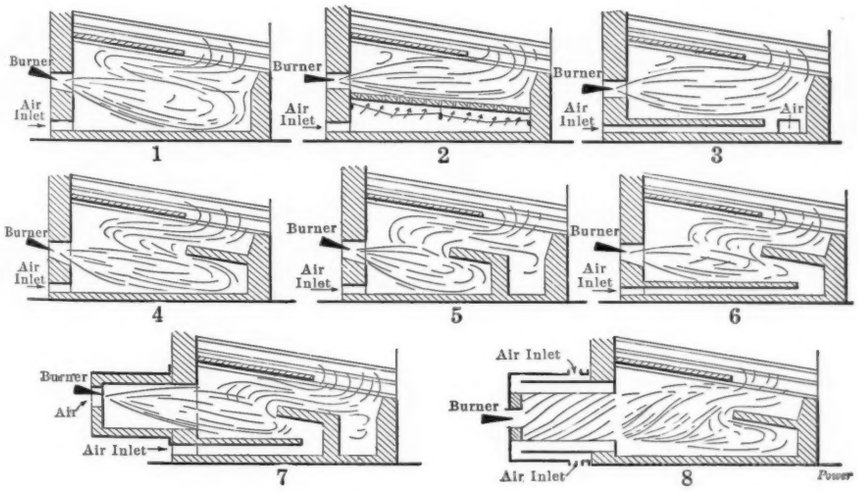


FIG. 1. OIL-BURNING FURNACES FOR WATER-TUBE BOILERS

1. Square, open furnace from which grate bars have been removed.
2. Grate paved with firebrick.
3. Furnace with hot-air floor. Additional air opening at side.
4. Furnace fitted with flat arch.
5. Flat arch with combustion chamber behind arch.
6. Hot-air floor and arches.
7. Extension furnace, hot-air floor, arches and combustion chamber.
8. Extension furnace, special, spiral, air-heating device for use with mechanical burners or for burners for high efficiency.

Double Eccentric

In the February 15 number, C. A. Eckerd asks about the advantage of two eccentrics.

The chap that got up the two-eccentric business had a condensing engine. The best diagrams he could get had exhaust lines like the bottom of a Chinese shoe. Even then the eccentric had to be advanced so far that the longest cutoff he could get was one-third stroke.

He put on an eccentric to operate the steam valves and was able to get a good clean exhaust line. By setting the steam eccentric at 90 degrees to the crank he could get any cutoff up to three-fourths stroke.

This long cutoff is not necessary in general work but he was driving a rolling mill and the extra eccentric was a great improvement.

W. E. CRANE.

Duluth, Minn.

Cylinder Lubrication

Having read so much about cylinders and having obtained so many pointers, I want to contribute my experience.

In our plant there are two engines, one 40 and the other 20 horsepower. The larger one is a high-speed, slide-valve machine made by the Oil Well Supply Company; it runs at a speed of 205 revolutions per minute. One quart of oil lasts for two and a half 12-hour days. The steam is very wet. The engine is 14 years old and in good condition still. Two years ago we installed a new set of rings and had the cylinder rebored. Aside from this we have had practically no repair bill during all the time it has been in operation.

The smaller engine runs at 70 revolutions per minute and uses half the quantity of oil.

The oil costs us 19 cents per gallon and is known as "Atlantic Red."

URBAN L. EISEMAN.

Oil City, Penn.

The first annual convention and exposition of the International Congress of Inventors will be held June 13 to 18, 1910, in the large convention hall at Rochester, N. Y. The exposition will contain exhibits of models of many inventions patented during late years. There will be a section devoted to the display of inventions of curious and unique devices patented during the early part of the last century; showing by contrast with present achievements the progress made in the matter of inventions, and there will be other instructive features. The association has nearly one thousand members. Those desiring to join, or who wish to secure space at the forthcoming exposition, should make application to Secretary Ralph T. Olcott, 123-125 Ellwanger & Barry building, Rochester, N. Y.

Low Pressure Steam Turbines

Discussion of the Stott-Pigott Paper before the Mechanical and Electrical Engineers. In Absence of President George Westinghouse, I. E. Moulthrop, of Boston, Presided

In the discussion following the reading of the paper, Dr. Charles P. Steinmetz explained that an induction generator differs from a synchronous (the ordinary type) generator in that it is merely a squirrel-cage induction motor driven at a speed above synchronism and "excited' inductively by a lagging current from the alternating-current circuit to which it delivers power, instead of having a field magnet excited by direct current from a separate source. He also explained at length—in fact, several times over—that the induction generator cannot generate at all unless connected to the same circuit with a synchronous machine, that it does not need to be synchronized before throwing into circuit, or to run in step after it is in, and that it delivers only "energy current," independent of load conditions, whereas the synchronous machine must run in step and may deliver leading, lagging or energy current, according to the character of the load.

Max Rotter, of the Allis-Chalmers Company, said that a difficulty which Mr. Stott had met with and evidently overcome, but which he had not touched upon in his paper, was the elimination of oil from the exhaust steam. He would like to know whether Mr. Stott would advocate installing a combined steam engine and low-pressure turbine as an initial installation. If the average improvement in economy is 13 per cent. over the best high-pressure turbine results, he should think that it would be better to use the combination than the straight high-pressure turbine; but he questions that figure. He thought that 8 per cent. would be nearer right. There are cases where with favorable conditions the high-pressure condensing turbine will show up just as well as the combination of engine and turbine, but not on a 25-cycle case, where the turbine runs at low speed, and, therefore, not under favorable conditions. He was a little doubtful as to whether Mr. Stott was comparing the 7500-kilowatt high-pressure condensing turbine with a 7500-kilowatt low-pressure condensing turbine, or whether he was comparing a high-pressure condensing turbine of a capacity equivalent to the combined capacity of the engine and turbine with the combined unit, which would really be the proper comparison. The feature which that particularly bears on is the cost of the condensing apparatus, which for a 7500-kilowatt high-pressure condensing turbine would not be the same as for a 7500-kilowatt low-pressure turbine; in fact the condensing apparatus for a 15,000-kilowatt high-pressure condensing turbine would probably be about the same; although it might use a little more steam it would not have to contend with the air leaking into the system, which would naturally reduce the efficiency of the condensing apparatus of the low-pressure turbine.

The curve given shows recent guarantees on some high-pressure condensing units, but it is scarcely fair to assume that this is the best which can be attained with these units. Most builders are conservative enough not to guarantee any more than they have to. If they knew that the other fellow was guaranteeing 14 pounds, they did not care to go below 15.9, even though they might be able to do 12. A high-pressure condensing turbine, operating under the average conditions shown in these tables, that is to say, a machine having a maximum capacity of 15,000 kilowatts, operating with dry saturated steam at 175 to 180 pounds gage pressure, with a vacuum equivalent to 29½ inches, ½ inch back pressure, would readily carry a kilowatt with 13.7 pounds per hour. On the other hand, the great advantage of the combination is that the high-pressure condensing turbine of 15,000 kilowatts capacity at half load would be using something like 15½ to 16 pounds, whereas the curve of the compound engine and low-pressure turbine is a very flat one, due to the fact that the efficiency of the engine decreases as the efficiency of the turbine increases. With a machine of 4000-kilowatt rating, with the same steam and vacuum conditions and 100 degrees superheat, they have got down to 14 pounds.

Mr. Jungren called attention to the fact that test 51 figures out an over-all efficiency of 72½ per cent. of the energy derivable by the working of the steam between the given limits. This includes the losses of both generators. In No. 42 this figures up to 69.6; and another test figures up to 68.7. High-pressure turbines working under favorable conditions could reasonably be expected to give at least 70 per cent.; probably 70½. But half-load efficiencies would be quite considerably worse than with the combined units. Of course, the high-pressure turbine units would be considerably cheaper in first cost than a combination of this type, and it is probable that the efficiency of the high-pressure turbine could be improved if as much money could be put into its construction as into the combined engine and turbine. The vacuums obtained in these tests are quite remarkable and show what can be done when it is essential to obtain a good vacuum.

Edwin B. Dreyfus, of the Westinghouse Machine Company, called attention to the fact that in test 51 corrections had been made both in the engine and the turbine for moisture in the steam in figuring the consumption, which should be done only for the engine, if the combination is to be considered as a unit. He asked if the Rankine-cycle efficiencies, as given in the tables, were for tested or corrected conditions, and thought that such efficiencies, if they go on record, should be for actual test conditions. The difference in the Rankine-cycle efficiency between the engines and the low-pressure turbine indicated some opportunity for improvement in the turbine. Mr. Flanders, of East Pittsburg, has made quite a study of turbine efficiencies and has found that a high-pressure complete-expansion turbine, operating with 175 pounds steam pressure and 100 degrees superheat, will give the same Rankine-cycle efficiency as a low-pressure turbine at the same vacuum and with dry saturated steam. It is quite evident that about 5 per cent. additional economy is obtained by running the reciprocating engine with a variable exhaust pressure. When this pressure goes below that of the atmosphere, unless the connections between the engine and turbine are in very good condition, the vacuum is apt to be impared on account of leakage into the piping. Mr. Dreyfus had found, though, a number of low-pressure turbine installations where the low-pressure turbine is tied on to two or more compound reciprocating-type Corliss engines with moderately long connections, and they are getting vacuums at this time of the year in the neighborhood of 28 or 29 inches, and the over-all economies on the small 1000-kilowatt unit show an improvement in the results, comparable with those shown by Mr. Stott. He asked Mr. Rotter to submit data on his 14-pound 4000-kilowatt machine, and agreed with Mr. Stott that a gain in economy of 13 per cent. is quite reasonable when it is considered that this unit is operating on dry saturated steam. He knew of no complete-expansion turbine record in this country that had reached the 72½ per cent., of which Mr. Jungren had spoken. Some have gone as high as 67.8 per cent., but as far as he knows, the records of a complete-expansion machine that has gone above 70 per cent. are within closed doors.

Mr. Stott had mentioned in the first part of his paper that the maintenance

account of a complete gas-engine plant would be four to ten times that of a turbine station. To the best of their ability to collect information and judge of working conditions they had not found it to come up to this amount, and he believed that their experience corresponded to what had been found in England. According to a paper presented before the Institute of Electrical Engineers on November 17, 1908, and which was very thoroughly discussed at London, Dublin and Manchester, the prevailing opinion seemed to be that the maintenance cost of the complete gas plant would not very much exceed that of the steam turbine; in fact, the authors of the paper claimed it to be the same. When the producer and boiler-plant end is considered, reason for this statement will be found. As for Mr. Stott's statement that 1½ pounds of coal per kilowatt-hour approaches gas-engine results, Mr. Dreyfus felt safe in saying that the gas-engine people can largely bid one pound per kilowatt-hour on a 14,500-B.t.u. coal.

George R. Parker said that it had been his privilege in the last year or two to investigate a number of low-pressure turbine possibilities, that is, existing engine stations where the addition of a low-pressure turbine might be expected to result in economical and better over-all station results. He had been met with the question on every hand, and particularly from the smaller class of engineers and plant owners, "If, as you say, you can effect in a noncondensing plant an improvement of something like 80 or 90 per cent. in the actual power developed, without any increase in coal, and if you can accomplish the same results, with a very much less proportionate increase in coal in a condensing plant, why haven't you got this exhaust-steam turbine in every engine plant in the country?" And to the lay mind this question is a natural one. He believes that if he had said to these same men that they could improve the efficiency 15 or 20 per cent. instead of 90 or 100, they would have had a much larger volume of business today, but it looked too much like the man who comes around and wants to sprinkle chemicals on your ash heap and give you new coal.

An investigation of the subject at once brings to light the reason for it, however. In no engine, no matter how well designed, can perfect expansion be had in any one low-pressure cylinder, or any group of low-pressure cylinders, whereas in the turbine this condition of complete expansion is very nearly reached, and that in brief is the sum and substance of the low-pressure turbine.

Another question has often been asked, namely, the smallest size of plant in which an installation of this kind can be made to advantage; and while no accurate data are yet available, it is doubtful, to his mind at least, if in plants smaller than perhaps 300 or 400 kilowatts very satisfactory results can be obtained, due to the fact that the actual cost of producing power in small installations is not made up so largely of coal as of labor and the numerous standing charges which constitute a much larger percentage of the total cost. He added a word of appreciation for Mr. Emmett, who had early realized the possibilities of the low-pressure turbine and had pushed it through many early trials and difficulties, and he might add numerous failures, to his crowning achievement so ably presented in the evening's paper.

Mr. Samuelson, of Rugby, England, said that the works at Rugby were largely filled up with mixed-pressure turbine work, which was a field that it was hoped we would take up here. The low-pressure turbines which are employed on the other side are of all the different types, and all of them more or less equally successful. They had met with some practical difficulties in introducing them. In connection with hoisting machinery the Board of Trade regulations called for constant back pressure on the engine. They used heat accumulators in connection with the low-pressure turbine, and the vacuum or low pressure would go back on the accumulator and on to the engine and would throw the driver off his guard, so that he would overwind the gage and accidents have occurred by men being thrown into the pit. It is necessary to provide some means to stop this, and they have introduced a valve between the engine and the accumulator, automatic and simple in its action, which shuts off the supply from the engine if the pressure drops to the atmosphere or below the atmosphere. While this valve is shut, the accumulator will empty itself down to quite a low pressure and give a supply. They had tried this valve between the turbine and the accumulator, and it works equally well, but the accumulator capacity is very much reduced, and if you work between two and three pounds pressure limit, you cannot stop the machine for any length of time before high-pressure steam cuts in and operates the turbine.

John W. Lieb, Jr., said that it would be difficult to imagine a power plant better adapted than that of the Fifty-ninth street station for the installation of the equipment described. The large engine units capable of carrying satisfactorily 8000 kilowatts, with reasonably low labor and maintenance costs, and the station design allowing the placing of the low-pressure turbines without objectionable crowding. He believed that the author was somewhat optimistic in his estimate that it would be possible to realize as much as 20 per cent. of the installation cost from the sale of used apparatus. The results of the condenser tests are particularly interesting on account of the high rates of heat transference, considerably in advance of the results hitherto obtained. The paper is a notable contribution to the economics of power-plant engineering, and the apparatus described should serve to give a new lease of life to otherwise antiquated engine-driven equipments, although it would be difficult to find another case where the application could be made with such manifest advantage.

Dr. D. S. Jacobus had visited the plant of the Interborough company while the tests were being made and said that it did his heart good to see the way that it was gone at. The economy of a piston engine will not always be improved by 25 per cent. by this combination, because in the case of the engines at the Redondo plant of the Pacific Light and Power Company they, at a steady load, would run on about 24,800 B.t.u. per kilowatt-hour, and at about 20.6 efficiency, and taking the boiler efficiency at 76 per cent., to make it come somewhere near what can be had with oil, you would have for the engine a B.t.u. consumption of about 21,800, so that we have the ordinary compound piston engine at Redondo with an efficiency of 24,800 against 21,800 for the combined plants. But in the Redondo engine they have superheat of about 100 degrees. He thought that as a fact they were coming pretty near the gas-engine efficiency. They have 21,800 with saturated steam, but with good superheat you could get down to 20,000 B.t.u. per kilowatt-hour, and that is a pretty good figure when you take in the producer and all the rest of the apparatus. On the 15-day Redondo test with a variable load, and a lot of lay-over period for the boilers, they developed a kilowatt-hour on about 25,000 B.t.u. It is very questionable to his mind whether a gas-engine installation would do very much better on that character of load.

Mr. Barnes said that one of the reasons why the corrections did not check up properly may have been the fact that the moisture in the steam fed to the low-pressure turbine was rather high, amounting to as much as 10 per cent. The correction was supposed to be 2 per cent. for each. per cent. of moisture, which would give an actual correction of 20 per cent. The corrections were hardly expected to take care of quite that range, and, therefore, the discrepancy is not surprising. While the units installed at Fifty-ninth street were built, for good and sufficient reasons, as low-pressure turbines only, they could have been built without any appreciable complications as mixed-pressure turbines. High-pressure nozzles could readily have been added to the steam chest without affecting the size or external appearance appreciably, and made to give full output without low-pressure steam at all, taking high-pressure steam only, and that could probably have been done with a water rate which

would not be appreciably above 15 or 20 per cent. worse than the best water rate that could have been given had the machine been designed from the start for high-pressure operation. One of the surprises of the installation has been the smoothness with which it has been started up and operated. Each of the three units which are now running was put into service on a commercial load within 24 hours after steam had first been applied to the turbine. It would be interesting to hear from Mr. Stott in regard to the smoothness of operation of the engine, working under considerable overload, compared with their original rating and working noncondensing. Mr. Moultrop announced that W. R. Emmett, who had been closely associated with the development of the low-pressure turbine, was unavoidably absent, but had prepared a written discussion which was presented by Mr. Carroll. He naturally felt a strong interest in the subject of this paper, since it related to one of the most important and interesting engineering enterprises with which he had been identified. While some few applications of low-pressure turbines in connection with electric-generating engines have been put into operation before that which is described in this paper, such cases are relatively unimportant, and he thought that in all of them the application has been made to a station which was formerly operated noncondensing. The cost of fuel has increased and the cost of apparatus has diminished, so that we now find ourselves in a position where the question of investment is of much less relative importance than it formerly was, the value of the product being so very large in proportion to the cost of the apparatus required. For this reason it must be remembered that we generally cannot afford to use any apparatus but the best no matter how small its cost.

The operation of stations by turbines alone is simpler and generally more economical than that of stations which use reciprocating engines. The results shown by Mr. Stott's paper, however, should demonstrate to many station managers that they cannot afford to run reciprocating engines alone when such an improvement can be accomplished by the addition of low-pressure turbines. He regretted that Mr. Stott had not said more about the saving in investment and operation which has been effected by this installation. The great improvements accomplished have been largely contributed to by the increase of firing capacity, by changes in many of the boilers some time ago, and comparisons of the original conditions in this plant with the ultimate development of the present plan afford a very striking example of what can sometimes be done with an old station.

The results in steam consumption shown by Mr. Stott's tests are very decidedly better than the best results which have ever been accomplished with turbines alone, the advantage in water rate amounting to about two pounds per kilowatt-hour as compared with the best turbine results. It is possible that this station will never produce power more cheaply than the best modern turbine stations are now doing with equal fuel, but the difference cannot be great, and when the enormous saving is considered, the great value of this change will be apparent.

Some of Mr. Stott's curves would seem to indicate that the results accomplished by the turbines were inferior to those guaranteed or expected, while in fact all guarantees and expectations have been rather exceeded. The reason for this apparent discrepancy is that the curves have not been corrected for moisture in the steam, etc. Mr. Stott has reported the facts as they exist and as they are influenced by such methods of moisture separation as he has used. If the separation were more perfect, the turbine results as shown by the curves would be much better, and it is probable that with more experience an almost complete absence of moisture in the turbine steam can be provided for. In Schenectady where they are operating two large low-pressure turbines on exhaust steam from a reciprocating-engine plant, the steam as it goes to the turbine is almost completely dry. The reason for this is that the steam has to pass horizontally through a long pipe which ends in a separator and which is drained before it gets to the separator. This arrangement gives the steam ample time to throw down its moisture, and the last vestige of it is taken by the separator. In most applications of low-pressure turbines and engines such an arrangement can be provided for, while in the installation referred to in this paper the delivery of steam from engine to turbine is a downward direction and through very short pipes in which very little separation or collection of moisture into drops can occur.

Dr. William Robinson suggested a modification of design, making the central member as well as the shell fixed and inserting between the two a rotor sleeve, provided both on its interior and exterior surfaces with working blades, thus making two working chambers. Pass live steam through the inner chamber the whole length and then let it flow through the outer chamber to the same end at which it entered. The outer chamber will have more space, it is farther from the center of the machine, and there is room for more blades, greater surface, and consequently provision for a greater expansion. He figured that the outer chamber might be made to develop as much power as the inner chamber, and that the capacity of the machine might be doubled, without increasing the longitudinal floor space. The end thrust would be balanced. One remark, which occasioned a broad smile to pass over the audience, we will quote verbatim, lest we do the doctor an injustice if we attempt to interpret it.

"Now construct a different machine with the same arrangement of inner and outer working chambers. Let live steam be passed into both chambers at the same time; that, I figure, will give in the outer chamber at least twice the power, because of the leverage and distance from the center, including leverage and blade surface that will give us at least twice the power we have in the inner chamber, in that way giving us a machine at least three times the power of the present machine without increasing the longitudinal floor space occupied."

We understand that the doctor has taken out five patents on the turbine in its suggested form.

Mr. Schauber did not feel entirely satisfied with the way that the gas-engine question had been left. Mr. Stott's tests made a showing of something like 21,000 B.t.u. per kilowatt-hour. At the South Works of the Illinois Steel Company at South Chicago there is a station of four small units of 2000 kilowatts each, operating on blast-furnace gas. The records kept over a space of six months under working conditions, not test conditions, give a kilowatt at the switchboard at the expense of slightly over 15,000 B.t.u. per hour.

Dr. Jacobus pointed out that the 15,000 B.t.u. is computed from the lower heat value of the gas entering the engine. If they had to figure upon the producer efficiency and divide through by it and by the higher value they would get a great deal more than 15,000.

Mr. Dreyfus said that we shall come to the point some day when we shall put a low-pressure turbine in connection with the gas engine, availing ourselves of the waste-gas heat, which will be another application for the low-pressure turbine.

Dr. Steinmetz: There is an interesting and somewhat unexpected result shown by the curve, namely, that the efficiency was found higher when operating the turbine with varying nozzle pressure than when operating with constant nozzle pressure. The efficiency of the low-pressure turbine is higher from constant nozzle pressure, just as expected, but constant nozzle pressure of the turbine means constant exhaust pressure of the steam engine and with constant exhaust pressure and the varying load the efficiency of the steam engine falls off, leaving the maximum point at a rate that is so much greater than the gain of efficiency in the steam turbine that the combined efficiency shows a very great advantage in favor of the varying nozzle pressure. This illustrates the fact that the turbine side is much less sensitive to

variations of the operating conditions than the steam engine is, and that, therefore, to get maximum economy in the operating condition the engine should be favored. But that also throws a side light on one of the reasons why the Rankine efficiency of the turbine is less than that of the steam-engine part, because all the unfavorable conditions of operation must be thrown on the turbine side of the cycle to get maximum average resultant efficiency. The gain in efficiency from the addition of the low-pressure turbine is on the lower side of the cycle, and is due to the possibility of extending the expansion below the exhaust pressure of the low-pressure cylinder of the steam engine. It means that the combined apparatus gains by the turbine being able to do a thing which a reciprocating engine is not able to do. You have to keep that in mind when you compare the low-pressure turbine and steam-engine plant with a high-pressure plant. On the high-pressure side there is a similar feature. The high-pressure turbine, figuring the efficiency with the same quality of supplied steam, is inferior to the plant shown here, but there is the possibility of rising on the high-pressure side by superheat. Now the reciprocating engine in general cannot gain by superheat as much as the steam turbine gains, so that a comparison of that combined efficiency with saturated steam of a reciprocating engine and a low-pressure turbine with a high-pressure turbine is not quite fair to the latter.

C. O. Mailloux said that the most interesting subject of which he could talk to our European colleagues on a recent visit to Europe was Mr. Stott's installation of a low-pressure turbine. Mr. Stott has been able to obtain great results by way of improving an engine which is already one of the best of its class and giving the highest efficiency in the world. He regretted that the discussion had said so little of what could be done in the way of improving a poor engine. He took exceptions to Dr. Steinmetz's remark that superheat will not benefit very much a reciprocating engine. He thought that if superheat and a low-pressure turbine were attached to a poor engine we should have a revelation that would be more surprising than which had been unfolded this evening, especially if the steam has enough superheat so that as it leaves the reciprocating engine it will still be sufficiently dry to do its real work or a great portion of its work. He was impressed with the possibility of the low-pressure steam turbine when he saw some five or six years ago at a coal mine in France a steam engine used for hoisting, exhausting into a Rateau accumulator, which furnished enough steam to run a pair of low-pressure steam turbines, which produced an output equal to if not greater than that of the engine itself. As bearing upon the question of the elimination of oil from the condensate, Mr. Mailloux spoke of an engine which he had seen within two months in an electric generating station in London, driving an alternator of about 1500 to 2000 kilowatts, which had not had a drop of oil in its cylinder for nearly two years. It is lubricated with graphite. Before using graphite the engine was wearing out its piston rings very rapidly.

In his closure, Mr. Stott said that so far as the elimination of oil was concerned, they sent out specifications for separators calling for the elimination of oil, so that the residue should not contain more than 0.4 of a grain per gallon, which they had found by experience was an entirely harmless quantity to pass into the boilers; and while at first they did not get the results, they are getting along nicely now, using all the condensed steam that comes from the turbine. The separator now comes well within the guaranteed 0.4 of a grain of oil per gallon.

In regard to Mr. Rotter's inquiry as to whether he would recommend a combined turbine and engine for an initial installation, he said that if you got these engineering questions down too simple you would not need engineers at all—nothing but purchasing agents. The total cost of power is made up of two things—fixed charges and operating charges. The fixed charges net from 11 to 12 per cent. on the investment. He sketched upon the blackboard the curve of fixed charges per kilowatt above the base line, and the curve of operating and maintenance charges below the base line, the distance between the curves representing the total cost, showing in a striking way the impracticability of the use of high-priced plants with a low load factor. The cheapest plant possible is the one for the peak load, because you will find that the operating charges in 10 per cent. load factor are only about one-fifth of the fixed charges. On a 10 per cent. peak load he would not consider for a moment the initial installation of a high-efficiency plant of any kind. He thought the most insane thing of all was the idea of putting in a gas-engine plant because the stand-by charges are low. But if you get up to a high load factor, such as 40, 50, 60, 70 per cent., where the coal is expensive, then you can afford to expend almost any amount on the initial investment. Roughly speaking, if we call the cost of a reciprocating-engine plant 100 and turbine plant about 80, the combined plant will lie somewhere between the two, say roughly, about 90; that would mean that there are many cases where with a good load factor it would actually pay to install a plant, but what those cases are it would require an engineer to determine.

As to Mr. Rotter's remark concerning the inleak of air with a reciprocating apparatus, the trouble which they had with the first unit was due to the use of some old riveted steel pipe between the engine and the turbine. It was not surprising that they could not hold a good vacuum. On the later units which were piped with standard steel pipe with Van Stone joints put up with ordinary precautions, there was absolutely no difficulty in maintaining the vacuum. He noticed the other day, when the barometer was extremely high (30.65) on one of the turbines the vacuum was 30.1; on the other, 29.9. This turbine has only been in operation a short time and there are some leaks still in existence, and they were operating on *only* about 28½ or 29 inches.

With regard to turbine steam consumption and Mr. Rotter's 15.7 pounds on a 15,000-kilowatt turbine he would be glad to see any such results but they were not found out when he was investigating the subject. They got from one of the companies a curve showing what they expected they could do under the conditions of the Fifty-ninth street station. That curve lay between 15 and 16 pounds. Another company saw the curve in the paper and said "that is just what we can do." A third concern which actually had one of these turbines operating reported that it was just what they did.

He had said purposely that the maintenance of gas engines would be from four to ten times that of the turbine in order to get somebody mad and get some information on the subject. The information has not come out and he will stand by those figures until somebody proves them wrong.

So far as the operation of the engines is concerned, all that was done to them was simply to move the eccentric so as to reduce the compression under the higher back pressure. The operation has been absolutely satisfactory. One unit has been in operation since last July, running an average of some 16 hours a day, and up to the present time there is absolutely no indication that the maintenance cost of that engine has in any way increased.

The production of a kilowatt-hour on 15,000 B.t.u. by the gas engines of the Illinois Steel Company is all right—when they are running.

He agreed with Mr. Mailloux with regard to the possibility of making a much better showing upon a poor engine. Superheat will make an enormous saving on the ordinary duplex pump. There is also another point of iew, the more steam the engine uses the larger the turbine to be installed.

All the tests reported were run with ordinary operating loads subjected to continuous fluctuations of 15 per cent. approximately, plus or minus. It is quite conceivable that if they had been able to run on an absolutely steady load, these results might have been somewhat improved.

Power and The Engineer
Devoted to the Generation and Transmission of Power

To Smoke or Not to Smoke

The present age is one of conservation, of civic improvement and general cleaning up. We are all trying to economize, to prevent waste, to clean our streets, to flush our sewers, to take care of our garbage and reduce our doctor's bills.

The power-plant owner has a responsibility in this connection from which he cannot escape; he must not waste coal, for coal is growing dearer every year; he must not pump soot over the neighborhood, for people are getting into a frame of mind where they will not put up with such impositions.

Time was when a back alley was the proper place to throw dead cats and overripe cabbages; when a stream of sink refuse was allowed to course its way undisturbed along the path of least resistance. But that time has passed; the laws and even the police recognize the fact that one is entitled to life, liberty and the pursuit of happiness only as he leaves others free and happy.

For a long time, the ordinary individual has regarded the smoke from soft coal as a necessary accompaniment of industrial prosperity; he has pointed with pride to the towering stacks on the horizon and to the long plumes of black which formed his skyline. He has submitted without protest to dirty linen and a spotted face under the impression that these were badges of manufacturing supremacy.

He has even taken pride in his own chimney and has regarded fondly the rolling clouds of hydrocarbons as synonyms for thrift and industry.

Let us suppose our complacent manufacturer sitting in his well furnished library at home, reading his evening paper by the light of a new library lamp which his wife has given him Christmas "because gas light hurts his eyes, you know." Presently he is disturbed in his reading by fine flakes of soot falling on his papers, a rank smell of coal oil assails his nostrils, and he throws down his paper in disgust. Spots on his immaculate linen just donned for dinner, spots on his nose and even on his shining expanse of cranium; the papers and books on his table covered with a fine deposit of hydrocarbon.

Does he take pride in his new lamp, its smoking chimney and the evidences of thrift and industry belching from its summit? Not he; he characterizes that chimney by adjectives such as editors seldom use and he freely expresses his opinion of the maid who trimmed and lighted his new acquisition.

But he has merely brought home to his library the same treatment he has been according the premises of his neighbors for years past, and for the same reason, heedlessness and neglect.

The same care and attention to business which insure a clean reading lamp will insure a clean furnace. A regular supply of fuel, a regular supply of air properly distributed, a high temperature with absence of chilling surfaces and there you are—a bright yellow flame, no smoke, perfect combustion. An uneven wick and an uneven fire bring the same punishment; a dirty wick and dirty coal both invite trouble. Just suppose we tried to feed a lamp flame with oil as some people feed a fire with coal, a scoopful now and then and long waits between.

The problem of clean chimneys is no longer a difficult one from an engineering standpoint and any number of manufacturers have met it and solved it. In almost any large city, there are chimneys which rarely if ever offend; why? Just because their owners are uptodate engineers and public-spirited citizens.

Smoke abatement means in the majority of plants the use of mechanical stokers and mechanical handling of the fuel. It means some care in the selection of fuel with reference to the type of furnace employed. But it also means a good return on the investment on account of more perfect combustion and cleaner flues.

Perhaps it would not be amiss to go to the metallurgist for some points on good combustion and to study the methods adopted in the open-hearth furnace.

A burning of coal carried out and perfected in a separate chamber under high temperature and forced draft, the gases brought into contact with the cooler metal only after combustion is complete, the utilization of waste gases to heat the incoming air, and smoke is an impossibility. If this is an economical method of melting iron, why will not some modification of it be an economical method of boiling water?

And let us not forget that after all, this is as much a problem in ethics as in engineering; that people are beginning to wake up to their rights; that everyone has as much title to pure air for breathing as to pure water for drinking, and finally, that the man who allows

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black smoke and soot to escape from his chimneys is not only a poor manager but an undesirable citizen.

Steam Pressure and Temperature for Heating

Many heating boilers are blown up because the attendant, in his desire to get more heat out of the system, subjects the boiler to a greater pressure than its design and construction warrant. The attendant evidently reasons that if a pressure of five pounds gives him a certain amount of heat, ten pounds will give him twice as much, but this does not follow. The temperature of the steam and its contained heat do not increase in proportion to the pressure. The effectiveness of a radiator depends upon the difference in temperature between the steam within and the air without, and the ability of the hot air to get away from the radiator. The tendency of air coming in contact with the radiator is to envelop the heating surface as it rises, thus protecting the upper parts from contact with the cool air of the room. That is one of the reasons why a high radiator is not as efficient as a low one.

One can thus see that a point is soon reached where, owing to the inability of the air to reach the heated surface and to get away from that surface, little is to be gained in heating effect by raising the pressure, and consequently the temperature, of the steam. As a general proposition, the most satisfactory results are obtained when the difference between the temperature of the steam in the radiator and the temperature of the air surrounding the radiator is about 150 degrees. When these conditions obtain, one may count on throwing off about 1.8 B.t.u. per square foot, per hour, per degree difference of temperature. If the temperature of the air in the room is assumed to be 70, this would make the desired temperature of the steam in the radiator 220 degrees, which corresponds nearest to five pounds gage pressure, and that is, in general, the best pressure to carry on a steam-heating plant.

When the pressure is raised from five to ten pounds, it is increased one hundred per cent., thus doubling the strain in the boiler and reducing its factor of safety one-half, but the increase in the working difference of temperature of the steam, and, therefore, in the amount of heat radiated, is only eight per cent. When the pressure is raised from five to fifteen pounds, the pressure is increased two hundred per cent., thus making the strain in the boiler three times what it was before, yet the gain in working difference of temperature is only fourteen per cent. Raise the pressure from five to twenty pounds, and thus increase the strain in the boiler three hundred per cent., or four times what it was at five pounds, and one increases the amount of heat radiated by only twenty per cent. These figures show how little one is warranted in increasing the pressure for the sake of a slight gain in the amount of heat radiated, an amount which is offset by the increased consumption of fuel, to say nothing of the added strains in the boiler.

Though somewhat foreign to the above, we wish, while on the subject of heating boilers, to point out that the Board of Boiler Rules of the Commonwealth of Massachusetts recognizes the necessity of two things that are not always recognized by the men who install heating boilers. One is that each boiler shall have a fusible plug properly placed, and properly taken care of, and the other, that there shall be a check valve in the return pipe, two eminently proper requirements that should be fulfilled in all installations.

Yellow Engineering

A most excellent sermonette on imitations was printed in a recent number of the little monthly bulletin published by the Bessemer Gas Engine Company—so excellent that we reprint here a few extracts from it.

All honorable business concerns look on counterfeiting as despicable. It is a sad commentary on American business that the business pirate still exists to prey on legitimate concerns. You know how it is. A success is made, and immediately comes the imitator, the counterfeiter, the manufacturing ape to prey on the success of the originator. Fortunately, the imitator usually dies an early business death. Without initiative, without brains, with only the monkey-like attributes to do what he sees someone else doing, he cannot survive. A worm does not live long either, but it is mighty annoying until you brush it off your neck.

Counterfeiters always have been, always will be, but if you always buy from an originator—the one who had initiative, the one who does something better than others and has established a reputation, you will not get a counterfeit.

Back many years ago, Stradivarius made violins better than anyone else. Today a "Strad" will bring thousands of dollars, yet violins that look like them can be bought for four dollars.

You can buy a safety razor for ten cents, one dollar, or five dollars. There are more of the latter two sold than the imitation at one-tenth or one-fiftieth the cost.

The makers of Tiffany jewelry are building on a solid foundation. No one knows the names of makers of cheap jewelry that may look like Tiffany's.

Let us go into the mechanical world where we are better acquainted. You can buy babbitt metal for ten cents a pound that looks like genuine babbitt.

You can buy tool steel at ten cents a pound that looks like the seventy-cent high-speed tool steel.

The difference is all in quality and service.

How can you distinguish between the genuine and the worthless? By dealing with those in whom you have confidence, with the originators, those who must stand or fall on the merits of their product, not those who have stolen the ideas of others and prey on the reputation which those others have gained.

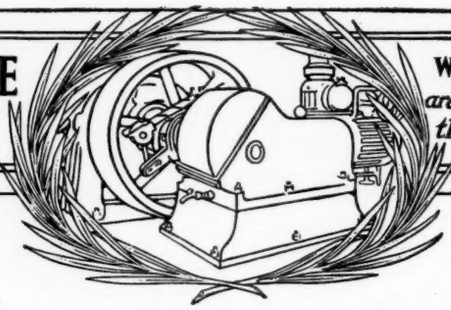
Did you ever know any imitation to be as good as the original, be it soap, soup or engines?

The force of the foregoing argument will be conceded by every fair-minded buyer of anything, and ostentatiously applauded by those builders who are copyists but haven't been detected—or think they haven't. There remains, however, the insuperable obstacle of frail "human nature" to impede progress in the direction of universal commercial rectitude. Few of us have the moral backbone to pay the originator a dollar if an imitator offers what seems to be exactly as good an article for seventy-five cents—more's the pity. If we had, there would be no engineering, industrial or commercial pirates.

Piracy in industrial engineering has become flagrant and widespread to an almost alarming extent, and a particularly discouraging feature of the game is that the pirate himself seems to be a moral idiot—devoid of the ability to realize the true character of his offense. Not long ago, in the course of a conversation between the present writer and a well known manufacturers' agent, the latter expressed a leaning toward the establishment of a factory for building a certain line of machinery. Upon being reminded that expert designing and considerable experiment would be necessary to develop a satisfactory line, he coolly said: "Oh, h—l; I wouldn't do that. I'd simply buy one of each machine of the best make on the market and copy it." And he was obviously ignorant of the contemptible character of such a policy.

Speaking of turbine possibilities, M. Battu, the American representative of the Rateau interests, says that with 195 pounds gage initial pressure, 150 degrees Centigrade of superheat and 28.75 inches of vacuum, a turbine can be made to run on 11 pounds of steam per kilowatt-hour and that he would be willing to guarantee that performance and to accept a penalty of $5000 for every pound that he required above the guarantee. This would be an efficiency of over 73 per cent., yet M. Battu says that such a unit of 8000 kilowatts capacity has probably been already sold and will be manufactured and put into operation in Europe.

NEW POWER HOUSE EQUIPMENT

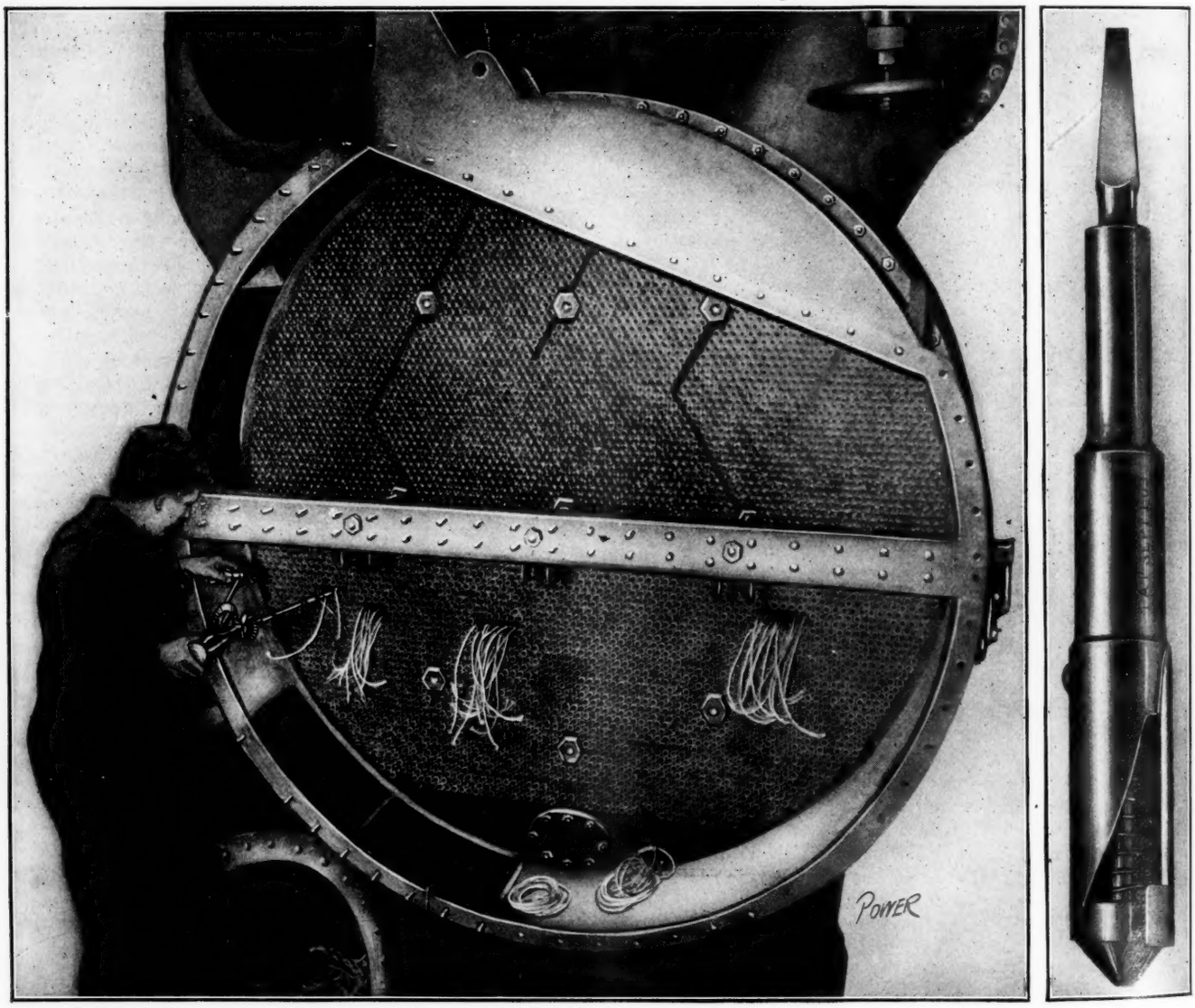


WHAT *the* INVENTOR *and the* MANUFACTURER *are* DOING *to* SAVE TIME *and* MONEY *in the* ENGINE ROOM *and* POWER HOUSE

The "Star" Condenser Packing Tool

A marked reduction in the time required for the packing of condenser tubes may be made by the use of the tool shown at the right of the illustration. In its construction the straight portion of the pointed center which telescopes in the body of the tool is of the same diameter as the condenser tube. When using the tool one end of the packing which has been cut to the proper length to fill the stuffing box is pushed to the bottom of the box and given about one-half turn around the tube. The tool is then placed against the end of the box. The free end of the packing is then passed under the lip of the outer shell and the tool is turned by a breast drill, brace or cross handle, and the packing automatically packs itself in the box.

The larger illustration shows the tool in operation on one of the condensers of the United States cruiser "Pennsylvania," where 1200 tube ends were packed in 5½ hours. Condensers have been packed with this tool and a water pressure of 5 feet head put on before the glands were screwed up without showing a leak. It is made for all sizes of tubes by Matteson & Drake, 24-26 Stone street, New York City.



CONDENSER TUBE PACKING TOOL

Lubricating Engine Cylinders with Graphite

Illustrated herewith is a device, patented by H. W. Miller, of 18, Kensington Court place, London, W., and C. M. Bennett, of 112 Holland road, London, W., for lubricating the cylinders of engines working with highly superheated steam with graphite. According to *The Mechanical Engineer*, of London, powdered graphite is blown into the cylinder in the form of a dust cloud, by the rapid and short application of a much higher pressure

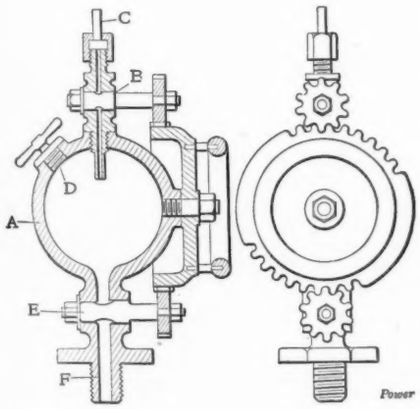
tube, the helical spring allowing the outer shell to slide to the bottom of the

and in this manner becomes well distributed over the working parts in the cylinder.

The high pressure for blowing in the graphite is obtained from the steam pipe on the boiler-supply side of the engine governor valve or regulating valve, and the injection of the graphite does not take place until after the admission of steam to the engine cylinder has ceased, that is to say, after the "cutoff" valve has closed and the expansion of the steam is taking place, and therefore the steam pressure in the cylinder will be considerably lower than the boiler pressure.

Timing the operation so that the graphite is injected at a given position of the piston in the cylinder can be done by making use of the motion of the engine such as, for example, the stroke of the piston rod to operate the cock controlling the admission of the higher pressure.

At each operation of injecting graphite the whole of the contents of the container is swept out by the steam and delivered into the cylinder. The quantity of graphite used at each operation is small, say, for example, from 1/20 to 1/10 of an ounce, according to the size of the cylinder, and when the engaging surfaces have become coated and impregnated with graphite, the intervals between each operation can be prolonged. The graphite container is of small cubic capacity and the amount of steam blown into the cylinder is also small and does not interfere with the regular and steady working of the engine. The container is placed close to the cylinder, so that its



LUBRICATING DEVICE FOR STEAM-ENGINE CYLINDER

contents can be discharged directly without the use of connecting pipes. One may be fixed to the center of the cylinder midway between each end, or a separate container may be used at each end of the cylinder.

The container used for the injection of the graphite is one of the well known types of engine grease cups, consisting of a globular casting *A*, the top end of which is provided with a quick-acting cock *B*, arranged to receive a steam pipe *C* which passes high-pressure steam into the containing chamber.

Near the top is an opening *D* provided with a screw-down plug through which the graphite is put into the containing chamber. At the lower end of the container a quick-acting cock *E* is provided which controls the discharge of the graphite through the passage *F* to the cylinder, the screwed shank being screwed into an opening in the cylinder. The handles for opening or closing the cocks *B* and *E* are interlocked so that they are moved together.

In order to lubricate the cylinder the required quantity of pure, dry, powdered graphite is first poured into the chamber through the opening *D*, the cocks *B* and *E* being closed.

The opening *D* is then closed by the plug, and finally the cocks are opened, this action causing the graphite to be blown into the cylinder through the passage *F*.

Renewable Valve Seats and Disks

The Nelson Valve Company, of Philadelphia, Penn., has recently put on the market a line of globe valves which are fitted with the Huxley patent valve seat. In Fig. 2 is shown the design of the renewable seat which is made of copper. Disks of leather, rubber, white

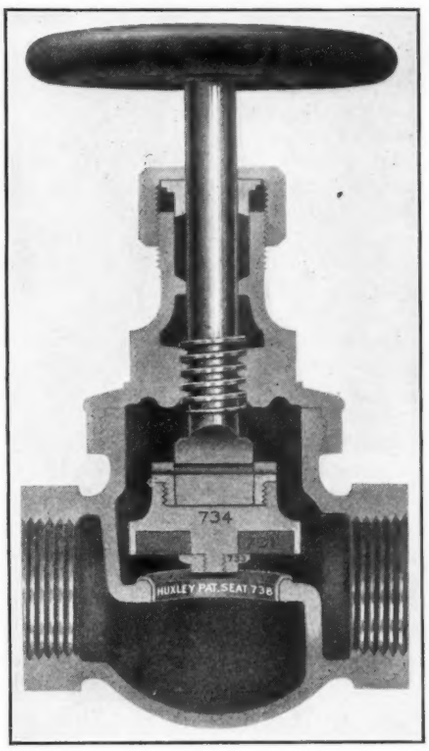


FIG. 1. HUXLEY VALVE FITTED WITH RUBBER DISK

metal, copper, bronze and brass are also furnished. The disk holders of all valves will fit disks of all materials, consequently a valve may be quickly prepared for a change of duty at a very low cost. Once a valve is placed in service, it need never be taken out for regrinding. When it starts to leak a new disk or seat can be put in. The whole operation can

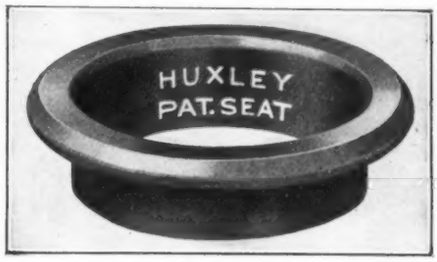


FIG. 2. RENEWABLE COPPER SEAT

be performed in but a few minutes. No tools other than a common wrench are needed.

Fig. 1 shows a Nelson valve fitted with the Huxley patent seat, disk holder and rubber disk.

Bursting of Flywheels and Pulleys*

Prof. Charles H. Benjamin, dean of the schools of engineering and director of the engineering laboratory of Purdue University, Lafayette, Ind., spoke before a joint meeting of the American Society of Mechanical Engineers and the Engineers Club of St. Louis, Saturday evening, March 12, on Recent Developments in the Bursting of Flywheels and Pulleys. A committee whose office was to adjust the relationship between the St. Louis branch of the society and the parent body was sent from New York to confer with the local officials and to be present at this meeting. The committee consisted of Jesse M. Smith, past president; Col. E. D. Meier, vice-president, and Calvin W. Rice, secretary.

Professor Benjamin's talk, which was well illustrated by lantern slides, brought out the fact that in the past there had been considerable danger attached to the study of the bursting of flywheels and he traced the development of the shields used to protect the observers from the flying pieces when the wheels disintegrated. The first experiments were begun twelve or thirteen years ago at Case school, using wheels 15 inches in diameter and patterned after the cast-iron flywheels in use on Corliss engines. For these experiments a screen of 2-inch pine was used, but it soon developed that this was not sufficient provision against the destructive force of the flying fragments. The next attempt at a shield was in the way of 6x12-inch oak timbers, the motive power as in the first case being a direct-connected Dow steam turbine, a tuning fork being used to determine the speed.

Twenty-four-inch wheels were finally tested, being shielded with 12x12-inch

*Presented at joint meeting of American Society of Mechanical Engineers and Engineers Club of St. Louis.

oak timbers, and the speed checked with a tachometer. Several views were shown of the destruction wrought on these heavy shields, showing that the most substantial wooden construction was still inadequate for the purpose.

The next development consisted of a 4x6-inch steel ring weighing 800 pounds, lined inside with wooden blocks and having ⅜-inch soft-steel covers at each side. This apparatus was located outside the laboratory building as it was thought that the experiments were getting too strenuous for indoor work. It was explained that the wooden blocks were used to prevent undue bruising of the flying pieces, it being important that they be recovered in as nearly as possible the exact shape in which they left the wheel.

After this apparatus, and another made of 1¼-inch boiler plate were totally demolished by the explosion of a number of 48-inch wheels it became evident that some other method should be pursued, and the latest method, copied after one used in Germany, is to place the wheels in a pit. In this construction the pit is lined with heavy concrete walls and a vertical shaft with ball bearings is supported on I-beams, the wheel to be tested being horizontal and a heavy bank of sand being provided to catch the flying pieces. The apparatus is driven by a belted 10-horsepower variable-speed motor, ranging from 800 to 2400 revolutions per minute. A tachometer, calibrated for slip, is also belted to the vertical shaft. This apparatus has been found perfectly satisfactory, and the sand stops the pieces without any bruising whatever, leaving them in the best of condition for study.

A series of sixteen 24-inch pulleys consisting of wood, cast iron, paper and steel, lately have been tested. Of these, the split-steel pulleys failed at speeds between 220 and 260 feet per second, corresponding to from 2100 to 2600 revolutions per minute.

The paper pulleys with solid web were considerably stronger, standing speeds up to 300 feet per second, or 2900 revolutions per minute. Two varieties of paper wheels were tested, one having the balancing in the web, and one in the rim. Those having the balancing in the rim always failed first, the weak spot produced by the balancing manifesting itself here on account of the greater centrifugal force.

Contrary to the general opinion it was found that sheet-steel pulleys were no stronger than those made of wood, when considered from the speed standpoint, the weakness of the steel pulley always being due to the joint in the rim. Professor Benjamin thought that a continuous rim would probably stand double or triple the speed.

In closing, the professor called attention to the fallacy of balancing pulleys with counterweights in the rims, when the pulleys were to be used for high speed. He cited one 48-inch wheel, having a 3½-pound counterweight on the inside of the rim, which weight, at the bursting speed of the wheel, exerted a centrifugal force of 2700 pounds, and was the direct cause of the failure of the wheel, the force of the weight being exerted at the weakest point in the rim. Another pulley which theoretically should have burst at 400 feet per second, really burst at about one-half that speed, or 1100 revolutions per minute, due to a balancing weight. This also emphasizes the bad effect of making a joint in a flywheel rim by adding metal, especially on the inside of the rim.

It is hoped in the future to make experiments with emery wheels, carborundum wheels, grindstones and so-called 100 per cent. joints in flywheel rims.

Mr Peak: Do you ever have any trouble with the vertical shaft in the new type of apparatus?

Professor Benjamin: Usually it requires a new shaft after each experiment.

Professor Hibbard: At the School of Engineering, University of Missouri, we propose to make some experiments with wooden aëroplane propellers, 6 feet in diameter and running at 1500 revolutions per minute. It has occurred to me after hearing the professor's talk, that there might be some danger in making these experiments and I would like to ask as to the advisability of erecting a bomb-proof for them?

Professor Benjamin: I would consider it extremely unsafe to make the experiment without having the propellers carefully inclosed. Anything going at a velocity between 200 and 400 feet per second is vicious and dangerous. A 6-foot propeller running 1500 revolutions per minute would have a peripheral velocity of 450 feet per second, which I would consider hazardous.

Mr. McPhearson: I would like to ask if you have ever investigated a flywheel construction with the rim joint at the center of the arms?

Professor Benjamin: This theoretically makes an almost perfect joint, any efficiency up to 80 or 90 per cent. being easily obtained.

Mr. Hugo: What is the greatest allowable stress in the rim of a flywheel?

Professor Benjamin: Cast-iron rims with no joints show between 390 and 420 feet per second as the bursting speed, or about 16,000 pounds per square inch. With half this speed there would be a factor of safety of 4. As the centrifugal force varies as the square of the speed, double the speed quadruples the force. This being known, any desired factor of safety may be obtained by varying the speed accordingly.

Mr. Ferguson: Have you made any experiments with friction-cutting disks of open-hearth flange steel? One in Chicago has been running at a speed of 450 feet per second for years without apparent deterioration. How would balancing such disks by punching holes affect the safety?

Professor Benjamin: Not much is known about the bursting speed of disks. Of course, a disk is stronger than a wheel, and I would consider that there was no danger of bursting at the speed mentioned. Balancing by punching holes I would consider rather risky.

Mr. Bausch: What experiments could there be made on full-sized flywheels?

Professor Benjamin: I think that 4 feet is about the limit for the ordinary institution or private individual.

Colonel Meier: I believe that this would be an excellent work for the Government to take up, as it has the testing of fuels of this country. The expense probably prohibits its being continued into the larger sizes by any other means.

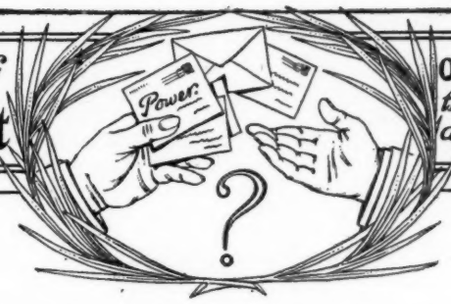
Jesse M. Smith: In regard to running disks at high speed, they have been in use for years at over 450 feet per second and it is common practice in steam-turbine work to run disks at 500 feet per second.

Failure of a boiler tube in the plant of the Railway Exchange building, Chicago, early Tuesday morning, March 8, scalded the night engineer and fireman so severely that they had to be removed to the county hospital. The tube was in the fourth row from the top in one of the Babcock & Wilcox boilers. It is believed that the night operators had some indication of a leak in the boiler and were making an examination when they were caught in a rush of escaping steam. The engineer suffered burns on the head, arms and body, while the fireman was less seriously injured.

The further use of the natural gas resources of the Province of Ontario is shown in the following report from Consul Harry A. Conant, of Windsor:

On November 1, natural gas was turned into the mains and service pipes of the local gas company, which before had been used to supply the city with artificial gas. The natural gas is piped from the Tilbury fields, 40 miles northeast of this place. Only the gas used for illuminating is purified, and this is done by individual purifiers placed on the premises of each consumer. For fuel the gas is used in its natural state. With few exceptions this gas will be used by the people here for fuel purposes, but its use is not so general for illuminating, many preferring, even at greater cost, electricity for this purpose. The price charged for natural gas is 25 cents in the winter and 30 cents in the summer months per 1000 feet. Experts declare that developments in this field show a supply that cannot be exhausted in less than twenty years.—*Ex.*

INQUIRIES of General Interest



QUESTIONS are NOT ANSWERED UNLESS they are ACCOMPANIED by the NAME and ADDRESS of the INQUIRER.

Volumetric Efficiency of Air Compressors

I take indicator diagrams from the air cylinders of compressors to measure the volumetric efficiency, which, of course, is at its maximum when valves, springs, piston rings, etc., are properly adjusted.

This method of measurement has passed muster for the past twenty years, but I now have a case where the engineer disputes this method of ascertaining the performance of the compressor in regard to its volumetric efficiency. Could you favor me with a letter, giving your opinion on this point?

H. S. P.

The conclusion from many experiments has led to the conviction that there is no convenient method of measuring air flowing through a pipe that is accurate and that direct displacement is the only way of accomplishing its measurement.

There are two ways of employing displacement for measuring compressed air, as the output of an air compressor, but it is a difficult thing to use these methods on a compressor which is actually doing useful work at the time the experiments are carried on. In other words, the output of the compressor must be diverted for the time being and by obtaining its actual volumetric efficiency under a given set of conditions the quantity of air being delivered to the work under similar conditions can then be accurately calculated.

The first displacement method is by allowing the compressor to discharge into a receiver in which the pressure for which the compressor is designed to operate, is maintained, while the air from this receiver is allowed to pass through a valve capable of accurate adjustment, into a second receiver whose volume is known. By counting the number of revolutions of the compressor during the time that it takes to raise the pressure in the second receiver from atmosphere to the discharge pressure of the compressor while the compressor itself is actually pumping against the correct discharge pressure in the first receiver, a measure of the air delivered by the compressor for a given number of revolutions is obtained. It should be remembered, of course, that the second receiver starts out full of air at atmospheric pressure and ends up with air at the discharge pressure and the temperature at starting being in all probability atmospheric, it is essential to know the temperature at the finish in the second receiver. Knowing the volume, pressure and temperature of the air in the second receiver both before and after the experiment, a little thermodynamics will make it possible to calculate the quantity of air put into the second receiver for a given number of revolutions of the compressor.

The other displacement method of measuring air from the compressor is to allow the air to replace water in a convenient-sized receiver, counting the revolutions of the compressor during the time that the water level in the receiver is being lowered a given distance. Pressures, temperatures and volumes must be known at the start and finish and suitable pipe connections must be made for handling the air during, before and after the experiment while the compressor is running.

Air Compressor Horsepower and Area of Segment

Please give formula for finding horsepower of pump from amount of air pumped; also a formula for finding area of the segment of a circle.

T. E. H.

The indicated horsepower of an air compressor for each 100 cubic feet of piston displacement per minute may be determined by the formula

$$I.H.P. = 1.51\ P_1\ (R^{0.29} - 1)$$

in which

P_1 = Absolute initial pressure,
R = Ratio of compression.

The ratio of compression is found by dividing the absolute delivery pressure by the absolute initial pressure.

The area of the segment of a circle is approximately

$$\frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H} - 608}$$

where

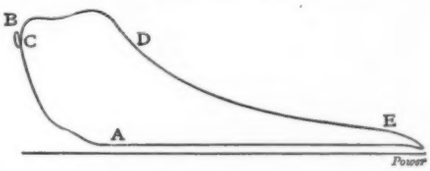
H = Hight of segment,
R = Radius of circle.

Steam Valve Opens Late

What is wrong with the engine that made this diagram?

W. R. J.

An indicator diagram is a record of what takes place in the cylinder of the engine during that stroke. As horizontal distances represent volumes or piston travel, and vertical distances pressures, you can by following the line traced by the indicator pencil note each event in the stroke. Starting at the exhaust closure *A*, the compression curve rises until the piston stops at the end of its travel, *B*. The piston now starts on the return stroke, but as the steam valve is not open, the pressure of the



steam in the clearance space falls as the piston moves until the steam valve opens at *C*, when the pressure rapidly rises to the level of the initial pressure, where it remains nearly constant until the steam valve begins to close. After cutoff at *D* the steam expands to the end of the stroke. The sharp drop near the extreme right denotes the opening of the exhaust valve. The steam valve opens too late.

Plante and Faure Storage Cells

What is the difference between the Planté and the Faure storage battery?

A. B. E.

In the Planté type the active material is formed on the surfaces of the plates by repeated charging and discharging. In the Faure type the active material is prepared beforehand, as a paste, and pressed into the interstices of a supporting grid.

Alternating-current Wires in Pipes

Why are two wires of opposite polarity placed in one iron pipe in alternating-current conduit wiring?

A. B. E.

In order to prevent excessive self induction in the wires, which would cause an abnormal voltage drop.

Armature Reaction

What is armature reaction and what are its effects?

A. B. E.

The influence exerted by the armature current upon the field magnet of a dynamo or motor is called "armature reaction." The effect is to distort the distribution of magnetic flux in the airgap and either to strengthen or to weaken the field magnet, according to the reaction.

Detroit Industrial Exposition

Detroit is to hold a great industrial exhibition under the auspices of the Board of Commerce, June 20 to July 6, to accelerate the commercial and industrial interests of the city. The exposition grounds will be on the Detroit river, where a huge exposition building will be erected and used in conjunction with the large Wayne pavilion. Plans have been made to accommodate between 250 and 300 exhibits, and the display promises to be one of the most unique and extensive outside of world's fairs. It is claimed that 100,000 different articles are manufactured in the 3000 shops of the city, the products ranging from pins to steamships and including a variety that is rivaled by the outputs of few American cities. Not only the products of Detroit's factories will be shown, but also processes. Running machinery will demonstrate the most modern methods of transforming raw materials into higher finished articles. The various industries are classified and grouped with a view to securing harmony and interest. In one building the general departments will be machinery, metal products, paints, electricity, building supplies, rubber, leather and paper products, drugs and chemicals, tobacco, food products, novelties and specialties, while in the other building will be automobiles and accessories, wagons and carriages, furniture, textiles, boots and shoes, house furnishings, jewelry and scientific instruments.

The exhibition will not only be educational but entertaining. Large bands will furnish concerts afternoons and evenings, and the decorative and illuminating features promise displays of great beauty.

OBITUARY

After a brief illness from pneumonia, Robert Kermit McMurray, chief inspector of the New York department of the Hartford Steam Boiler Inspection and Insurance Company, died at his home in Brooklyn, N. Y., on March 8, in his seventy-fourth year.

Mr. McMurray was born on February 23, 1837, in Brooklyn. In 1858 he went to work for the Baltimore & Ohio Railroad Company, and remained with this road until the outbreak of the Civil war.

During the war he made an enviable record while serving with the Thirteenth Regiment, Engineers, National Guard, New York. Under his supervision the first military railroad was constructed. After the war he resumed work for the Baltimore & Ohio until 1867, at which time he held the position of road supervisor.

He joined the Hartford Steam Boiler Inspection and Insurance Company in this year in the capacity of inspector and was assigned to the New York territory. As the business grew, he was made chief inspector, in which position he continued until his death.

Mr. McMurray designed and erected a great number of common-brick chimneys before the advent of the patent-block stacks. The most notable among the chimneys which he built was one for

ROBERT KERMIT MCMURRAY

the Clark Thread Company, at Kearney, N. J. Its hight, over all, is 347 feet and it has a flue diameter of 11 feet. Nearly two million bricks were used in its construction. It was completed in 1888. At that time it was the tallest and largest chimney in America. Today it is the tallest and largest chimney constructed of common brick in this country and is a magnificent specimen of sound engineering practice.

Entering the boiler-inspection business when he did, the history of his achievements parallels that of the organization itself, for he was one of the original few who believed that the inspection and insurance of steam boilers had a great part to play in protecting steam users from disastrous loss of life and property. At the time of his death he was known as the "dean of steam-boiler protection."

SOCIETY NOTES

The fifth anniversary and annual ladies' night of Progressive Council No. 12, of the Universal Craftsmen, Council of Engineers, was held at the council rooms, on Broad street, Newark, N. J., on Friday evening, March 4. In addition to a program of instrumental and vocal selections and recitations, a feature of the evening was the presentation of a past chief's jewel to C. E. Barnes, just retiring from office. The presentation was made by the senior past chief of the council, Albert W. Whitehead. A large number of members and guests were present, including visitors from nearby cities. Among those who participated in the entertainment in addition to Mr. Whitehead, who delivered the address of welcome, were Miss Adelaide Ward, Robert Hannah, Miss J. C. Condit and Mrs. William T. Wilson in vocal solos; Miss Elsie Bennett and Robert Wilson, piano duet; Miss Pearl Holzhauer, recitation; Miss Hazel Nelgert, violin solo; Miss Mabel Warfield, piano solo; C. A. Barnes and brother, musical selections; C. A. Kurzel, accompanist. Refreshments were served at the close of the festivities.

The American Society of Mechanical Engineers held a meeting in Boston, Friday evening, March 11, in the Lowell building of the Massachusetts Institute of Technology. M. W. Alexander, Lynn, Mass., presented a paper on "The Training of Men—A Necessary Part of a Modern Factory System." The paper was discussed at much length by Henry E. Rhoades, past assistant engineer, retired, U. S. N.; Prof. Charles F. Park, and R. H. Smith, of the Massachusetts Institute of Technology; Prof. Ira N. Hollis, Harvard College; Prof. Gardner C. Anthony, Tufts College; Prof. Peter Schwamb, Massachusetts Institute of Technology; and others.

This was a joint meeting with the Boston section of the American Institute of Electrical Engineers. The chairman announced that the April meeting would be a joint meeting of the American Society of Mechanical Engineers, Boston section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers, conducted by the American Society of Mechanical Engineers. Professor Allen, of Worcester Polytechnic Institute, will present a paper on Water Wheels.

PERSONAL

Walter B. Snow, publicity engineer, Boston, announces that his office facilities have been more than doubled by removal to rooms 421, 422, 423 and 425, in the same building. Also that Benjamin Baker, formerly of the *Boston Transcript* and late editor of the *Navy*, and Herbert M. Wilcox, chemical engineer, experienced in various industries, have been added to his staff.

J. G. White & Co., engineers and contractors of New York City, announce that they have just made arrangements whereby C. A. Greenidge will be connected with the company as an engineer in the operating department. Mr. Greenidge is an engineer of long and varied experience and is a member of the American Institute of Engineers.